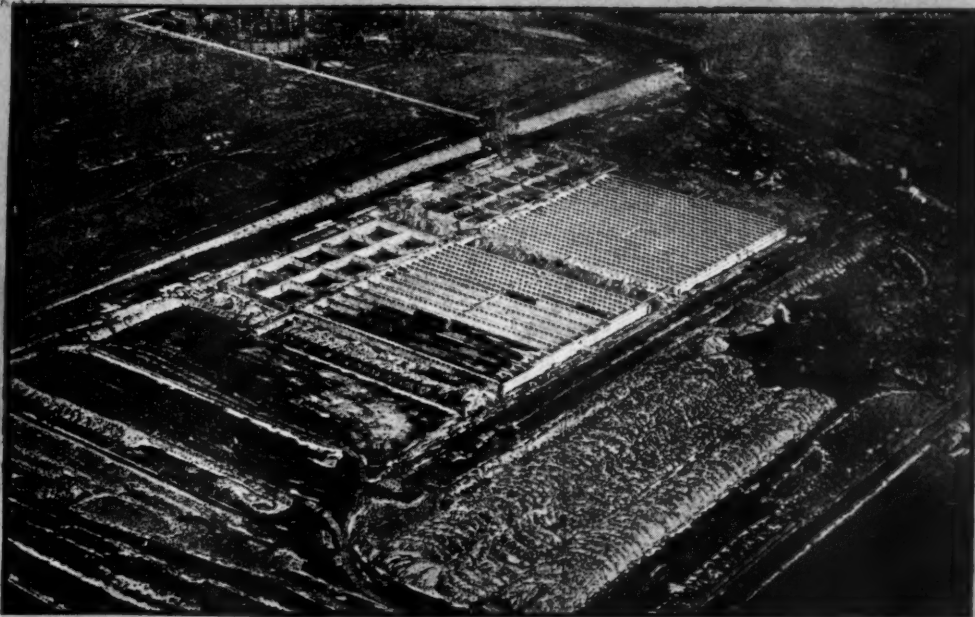


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# PUBLIC WORKS

CITY COUNTY STATE

A Combination of "MUNICIPAL JOURNAL" and "CONTRACTING"

Vol. 56

November, 1925

No. 11

## Street Railway Pavements in Denver

Stone block being replaced with concrete, with and without headers along the rails. Details of concrete construction. Use of construction trains prevents obstruction of streets during laying of pavement.

By Ivan E. Houk

Street railway pavements in Denver are constructed by force account, by the Denver Tramway Corporation, the corporation which owns and operates Denver's street railway lines. The total length of paved track in Denver today, reduced to a single track basis, is a little more than seventy miles, approximately thirty-six per cent of the total street mileage within the city limits. Since nearly all of the paved stretches are double track the equivalent street length is about forty miles.

The tramway company's franchise requires them to pay for paving the space between the rails and two feet outside each rail; a total width of 7.9 feet for each track in nearly all instances, since the system is mostly narrow gauge construction. Pavement wide enough for standard gauge construction is required only where the track is used jointly with the Denver and Interurban Railway Company. However, the tramway company with its own forces, paves a width of only 6.4 feet, 15 inches outside each rail, leaving 9 inches on each side to be paved by the city's contractor at the time of paving the dummy and the shoulders. These 9-inch strips are paved with the same materials as the dummy and the shoulders, generally concrete in

the dummy and sheet asphalt on a black base between the rails and the curbs. The cost of paving these 9-inch strips is billed to the tramway company by the city and paid for in cash.

Two general types of pavement have been constructed; namely, stone block and concrete. While some red sandstone block pavements have been built by the tramway company, most of their stone block pavements were laid with basalt block from quarries near Golden, Colorado, fifteen miles west of Denver. Stone block was used in the greater number of the earlier pavements, although some concrete was laid as early as 1901. Concrete has been the more usual type constructed since about 1907, and is now the standard adopted by the company, stone block being used only in repair work, or in occasional special instances.

It is interesting to note that the city of Denver has a total of 147,200 square yards of stone block pavements, including areas in the dummy and on the shoulders as well as streets containing no street railway tracks. The greater part of the stone block pavements constructed by the city have been laid with red sandstone block from quarries near Lyons, Colorado, fifty miles northwest of Denver. The city officials



FIG. 1—SANDSTONE BLOCK PAVEMENT AT BLAKE AND 18TH STREETS.

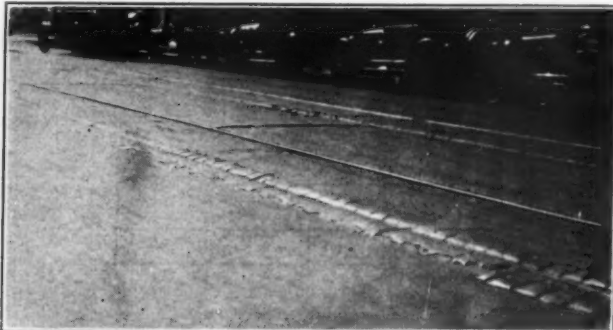


FIG. 2—STONE BLOCKS LAID ALONG RAILS, WITH CONCRETE PAVEMENT BETWEEN RAILS.

find that the basalt block have a tendency to polish under traffic, so that they become slippery. No new stone block pavements have been built since 1915.

From the standpoint of the city the stone block pavements have been satisfactory as regards both wear and low maintenance cost. However, the tramway company has found a considerable amount of maintenance necessary due to heaving of the block along the rails. Figure 1, a view of the intersection of Blake and 18th Streets, looking southeast on 18th Street, shows a typical red sandstone pavement in the older section of the business district. This pavement was originally constructed in 1892, although the street railway track was not laid until 1907. In the original construction the block were laid on a 2-inch sand cushion, spread over a 6-inch base course of 1-3-6, natural cement concrete. Joints between the block were filled with grout. This was the usual method of laying the stone block pavements except that Portland cement was used in later construction; also a 1-inch sand cushion was sometimes used instead of the 2-inch cushion. The picture shows that the block were laid diagonally in the dummy and outside the track, but transversely within the track. Beyond the intersection all block were laid transversely. The pavement is in good condition despite its 33 years of service on the shoulders and in the dummy, and its 18 years of service in the car tracks.

When the tramway company first began using concrete in their pavement construction they laid a row of stone block along the inside of each rail, to act as a header or flangeway, and also to permit access to the joints; and then poured the concrete between these headers. They also laid rows of stone block transversely, at intervals of from ten to fifteen feet, to serve as expansion joints. Figure 2, a view of 16th Street near Glenarm Place, shows this type of construction. The stone block headers, or flangeways, have not

proven undesirable from the standpoint of automobile traffic; but the transverse rows of block have proven very unsatisfactory. They wear down faster than the concrete, causing depressions in the surface which produce noticeable jars as the automobile wheels pass over them.

The principal advantage of the stone block pavements over concrete—accessibility of the rail joints—became of minor importance when the practice of welding the rails together was instituted. This, together with the facts that concrete is less expensive than stone block, that it is smoother and consequently less noisy, and that it is free from the objectionable, wide, filth-collecting joints, have led to the adoption of concrete as a standard. Today the concrete mileage comprises a large percentage of the total length of paved track within the city limits.

While the company varies the details of construction at times to meet particular problems, the standard cross section being used on most work is a two-course, monolithic slab, 9 inches deep, laid on a 9-inch foundation of tamped, pit-run gravel. Figure 3 shows the detailed design. The lower, or base, course is 5 inches thick, and is mixed in the proportions 1-3-6, using a screened gravel aggregate. Sometimes old paving blocks which are too badly worn to be relaid are placed in the base course, between the ties, to cut down the quantity of concrete needed as well as to dispose of the old block. The upper, or wearing, course is 4 inches thick, and is mixed in the proportions 1-2-3½, using a crushed basalt aggregate. The pavement is poured in sections about twenty feet long, so that the top course is deposited before the base course has attained its initial set, thus forming a monolithic slab. This type of construction has been found very satisfactory.

No reinforcement is used, and no transverse expansion joints are provided. The track construction tends to prevent the formation of wide cracks. Sixty-five pound rails are used in the standard construction. These are spiked to dip treated ties, 6 inches by 8 inches by 6 feet 6 inches in size, spaced 24 inches on centers. Tie plates are used to reduce tie wear and to lock the rail more securely to the ties. Expansion joints are placed along the edges of the track pavement on the dummy side, when the dummy is paved with concrete, more to act as cushions and to permit vertical vibration of the track slab, than to allow horizontal expansion and contraction. Transverse expansion joints are frequently used in the dummy when it is paved with concrete. Figure 4 shows this type of construction on Downing Street, a few blocks south of Cherry Creek.

A small concrete mixer and a small gang are used sometimes in paving odd jobs, like street intersections which are frequently paved under car traffic. However, most of the pavement work is done with an unusually efficient equipment consisting of a mixer mounted on car wheels, which can be moved along the track ahead of the concrete as the pavement is con-

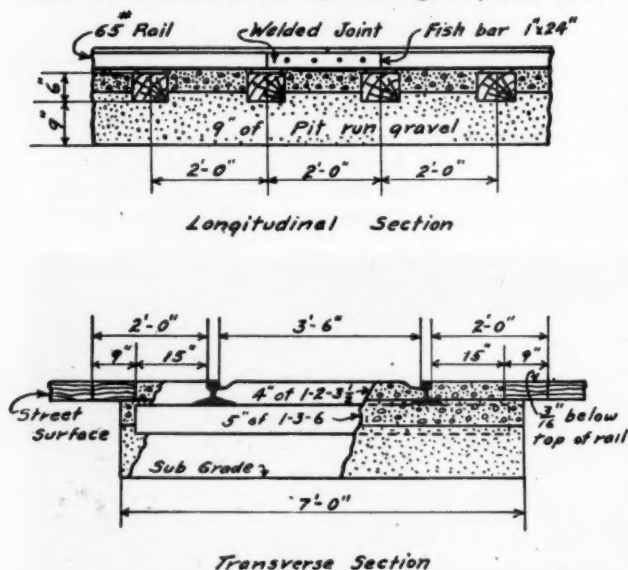


FIG. 3—DENVER TRAMWAY COMPANY'S STANDARD TRACK CONSTRUCTION IN HARD SURFACED STREETS.

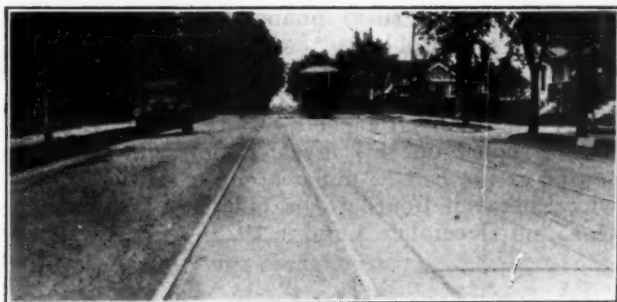


FIG. 4—CONCRETE PAVEMENT ON DOWNING STREET.

structed; and supply trains carrying ore dump cars filled with aggregate at a central plant. Figure 5 shows this outfit at work. Four supply

crete. The central plant is arranged so that trains are run under the bins and the dump cars loaded from above. Sacks of cement are placed on top of the dump cars as the train passes out from under the supply bins. However, the cement is not dumped out of the sacks until the job is reached. The dump cars are kept on two of the three tracks with which the flat cars are equipped, while being loaded and while in transit, so that the third will be ready to receive the empty cars without delay, as soon as their loads are dumped into the mixer skip.

The crew consists of about 15 men, exclusive of the foreman and motorman. Three laborers handle the work on the flat car; two men run the mixer, one man operating the skip while the

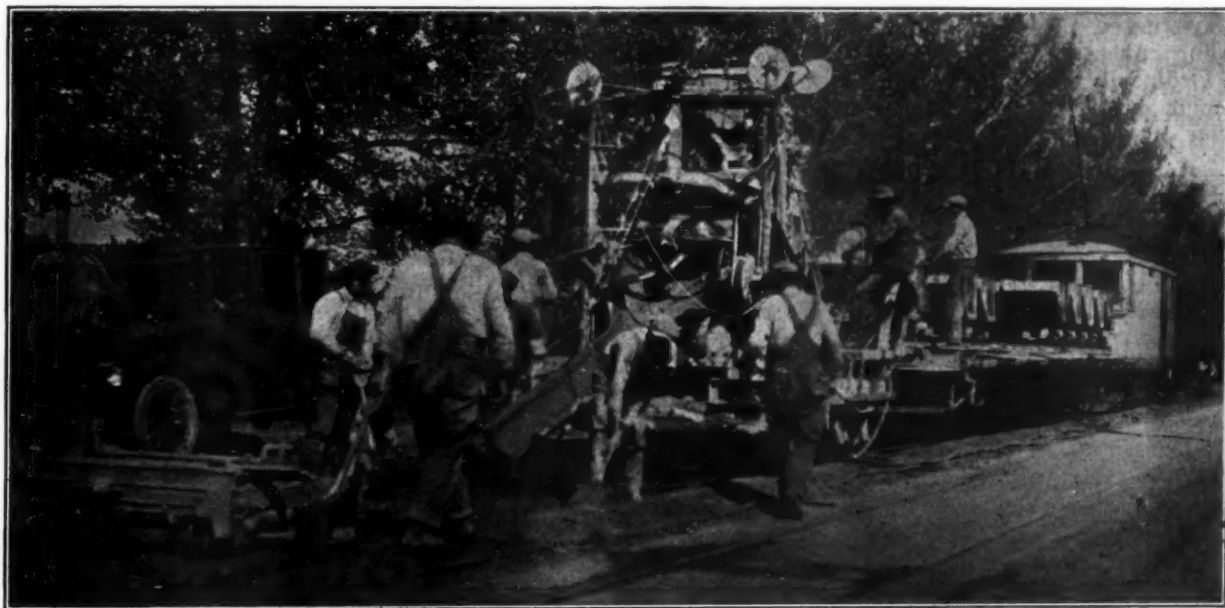


FIG. 5—THE DENVER TRAMWAY COMPANY'S CONCRETE TRAIN AT WORK.

trains are used in most cases, although sometimes, when the distance from the plant to the job is unusually short, a smaller number can keep the mixer working.

Four trains are able to keep the mixer busy when the job is not more than about four miles from the central plant. One train is supplying the mixing operations on the job, while a second is being loaded at the plant, the third and fourth trains being en route to and from the job. Each train consists of a motor car, to furnish the required motive power, and a flat car, equipped with three tracks, carrying 16 ore dump cars of 13 cubic feet capacity, each dump car being filled with a sufficient amount of coarse and fine aggregate to make a one-third cubic yard batch of con-

crete; six men rough spade the concrete into position and do miscellaneous odd jobs; and four men do the finishing. Figure 6 shows the gang

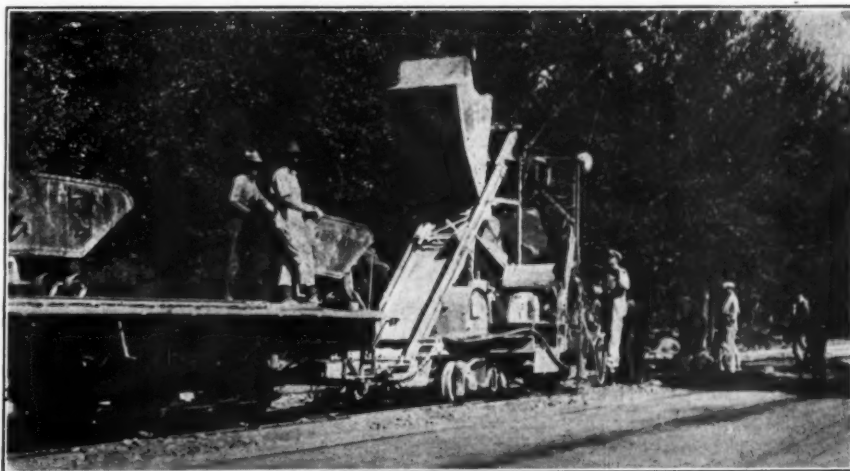


FIG. 6—STREET RAILWAY PAVING GANG AT WORK ON COLORADO BOULEVARD.

at work on Colorado Boulevard, one of the city's most heavily travelled boulevards.

An electrically operated tamper finishes the top course roughly, tamping the concrete between the ties and bringing the surface between the rails to a level with the tops of the rails. The surfaces outside the rails are made to conform with the adjacent street paving which is generally about  $3/16$  of an inch below the tops of the rails. The tamper also cuts grooves along the insides of the rails, to make room for the car wheels. Hand finishers remove the grout which collects in the grooves, and trowel the entire pavement surface twice. After the concrete has reached its initial set it is roughened slightly by brooming, and covered with about two inches of earth. It is then ponded for several days so that it will cure properly. Figure 7 shows the newly constructed pavement on Colorado Boulevard being covered with earth.

Ordinarily the pavement is allowed to cure ten days before being opened to traffic. However, in some cases calcium chloride, in the pro-

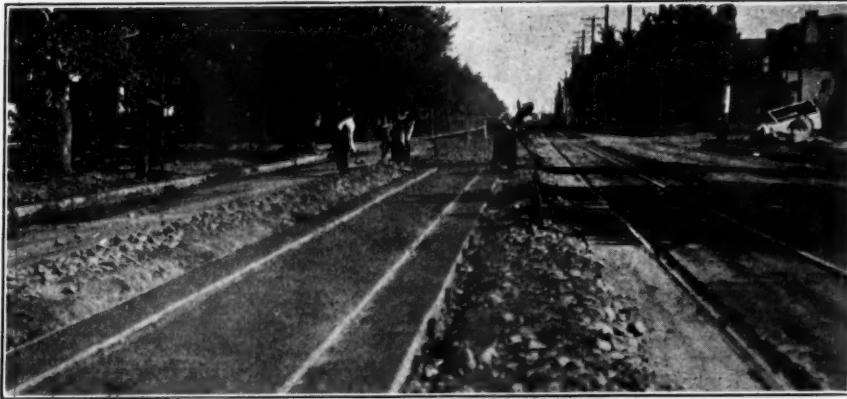


FIG. 7—COVERING A NEWLY CONSTRUCTED CONCRETE PAVEMENT WITH EARTH

portions  $3/4$  pound of chloride to each sack of cement, is added to the concrete to hasten the setting. In such cases the pavement is opened to traffic in five days. The calcium chloride is dissolved in large vats at the central plant, hauled to the job on the concrete train, and added to the concrete during the mixing operations.

This construction costs the tramway company approximately \$2.25 a square yard, exclusive of ballasting and track construction. The work can be carried on without blocking more than half the street at a time, since it is not necessary to dump materials in the roadway.

The foregoing information has been obtained through the courtesy of Nelson R. Love, chief engineer of the Denver Tramway Company, and A. K. Vickery, city engineer.

### Urban Highway Finance

An investigation of this subject has been begun by the Highway Research Board of the National Research Council, with Jacob Viner, Professor of Government Finance at the University of Chicago, in charge. The objects of this study are: to determine the relation of city

dwellers to the rural finance problem; to investigate the problems of city street finance including the financial problems of construction, maintenance and widening of city streets; and to study the financial aspects of city traffic control.

The report on this investigation will be presented at the Fifth Annual Meeting of the Highway Research Board to be held in Washington, D. C., on December 3 and 4, 1925.

## Equipment for Refuse Collection

**Motor equipment used in Chicago by municipal forces and in Kansas City by private contractor. Latter believes horse-drawn trailers during collection more economical.**

At the convention last month of the American Society for Municipal Improvements three

papers were presented under the general heading "Equipment for the Collection of Garbage and Other Refuse Materials," the authors being W. J. Gallagan, assistant superintendent of streets of Chicago; Paul Patton, a contractor of Kansas City, Mo., and R. E. Stoelting, commissioner of public works of Milwaukee, Wis.

Mr. Gallagan was prevented by sickness from being present to discuss the subject, but sent on a brief abstract of the information which he had to give. Beginning with a resume of Chicago's experience in collection, Mr. Gallagan said:

"There is, perhaps, no kind of municipal equipment which affords a wider variety of types than those used by the different cities for the collection of household waste. Like the methods employed in the final disposition of the waste itself, the style of the equipment in use for collecting and hauling seems to have received little study and scant attention. Apparently, each city has been content with its own particular type, making little effort to improve it.

"In 1905, when the City of Chicago entered into a contract for the disposal of its garbage by the reduction method, it became necessary to separate garbage from other household refuse, and a type of garbage wagon was adopted consisting of the ordinary wagon running gear with a steel, water-tight box of four cubic yards' capacity, with six steel sectional covers, the theory being the concealment of five-sixths of the load during the loading operation. These tanks can be removed from the wagon bed at the reduction plant or loading stations and empty ones substituted. This same type of

wagon is still in use, the equipment being owned by the city.

"Chicago's ashes and miscellaneous wastes have been hauled for many years in wooden wagons of special design of five cubic yards' capacity. Of late years, five-ton auto trucks of eight cubic yards' capacity have been employed also. The wagons are the property of individual owners, as are the trucks. Wagons with driver receive \$11 a day, while trucks receive \$27.50."

Mr. Gallagan then told briefly of the acquisition by Chicago of the motor equipment which was described in our issues of November and December, 1924, pages 335 and 378. This equipment included 33 tractors and 213 trailers. Concerning the results obtained by this motor equipment Mr. Gallagan said: "Our records show that for the first eight months of 1925, we saved \$300,152.32 over the same period in 1924 when the work was being done by wagons and trucks. Based upon the test of the past year with 33 tractors and 213 trailers, the city officials and engineers estimate that 142 tractors and 1,020 trailers are needed to cover the area within the city limits. The cost of these vehicles is placed at \$2,432,000. Supplementing them, the city would still employ 452 teams to collect from the unimproved alleys of the city. With that equipment, it is estimated that a large saving would be effected."

"Last year the collection of ashes and refuse cost \$2,570,190 and the hauling of garbage, \$638,125—a total of \$3,208,313. It is estimated that the same service in quantity but considerably better in character could have been rendered by the tractors and trailers for \$2,490,810, thereby effecting a saving of \$717,503. From this estimated annual saving of \$717,503 alone all the tractors and trailers required could be paid for in about three years."

BY PAUL PATTON

The discussion by Paul Patton, hauling contractor of Kansas City, Mo. (the Kansas City Collection Company) was as follows:

If time permitted us to make a comparison of operating costs of the different systems in vogue, we might make a study of statistical data on each system and thus arrive at some conclusion. It does not permit, however, even an enumeration of details, much less a comparative discussion of advantages or disadvantages of the different systems.

There are four general systems in vogue for collecting municipal refuse.

- I. All horse-drawn wagons.
- II. All motor trucks.
- III. A combination of horse-drawn wagons and motor trucks.
- IV. Trailers pulled by horses while collecting and by tractors while transporting garbage from route to disposal point.

The collection of municipal refuse divides itself into two distinct parts.

- I. The actual picking up of the material and placing it within the collection vehicle.
- II. The transportation of the loaded vehicle

from the area where the collection is made to the point where the vehicle is unloaded.

The first part of the entire operation is designated "primary collection." The second part of the operation is "transportation." The "primary collection" is concerned solely with a house to house service within the limited area usually assigned to two men. The transportation part of the operation may be a large part of it, or it may be a small part, depending upon whether the collection area is adjacent to, or a long distance away from, the point where the vehicle of the primary collection is unloaded.

The writer has been engaged in the transportation business for the past fifteen years. He believes that the tendency of the average buyer of motor trucks is to under-estimate rather than accurately estimate the expense of operating these trucks. This is especially true unless the truck is handled and cared for carefully. The parts of its machinery are necessarily small. Some of these parts operate at very high speed; they must fit with great accuracy, and clearance of one thousandth of an inch is the usual maximum allowance. The truck operates over all sorts of roads and under all sorts of conditions. It is usually driven by a man of no mechanical ability or mechanical experience, and of indifferent character. I believe that, unless the truck is guarded and protected by the driver and unless it receives the proper inspection and maintenance, the upkeep and depreciation make it more expensive than the average buyer believes it to be. To this must be added the fact that municipal management usually does not make for economy as does private management.

The horse and the motor truck, if rightly studied, are not competitors. The horse has a field into which, with economy, the motor truck cannot go. The motor truck has a field that the horse cannot invade. The advantage of the truck is in its speed, and in order to develop this advantage, the truck must be kept in motion a large percentage of the time it is working. Under conditions where the total mileage covered by a truck in a day is small, the horse is more economical than the truck. It is also true, however, that where the mileage is great the truck, on account of its speed, can do things that a horse cannot possibly do, and do these things more economically. To illustrate, a house-to-house delivery of milk or ice by motor truck seems to me to be an economic waste. On the other hand, the suburban collection of milk or the hauling of ice from a central manufacturing plant to distributing stations can be done more economically with trucks than with horses.

In Kansas City we have been collecting garbage with light trucks entirely. No horses whatever are employed. Our collection figures are by no means based upon as much data as I would like to have for them, but from the best information we can gather, the actual distance travelled per day in an area of an average density of population, to collect three tons of garbage on a basis of two collections per week in the months of July and August, will not exceed ten miles.

Our average haul will very closely approximate ten miles round trip. In other words, our trucks working ten hours per day travel ten miles actually picking up garbage, and twenty miles transporting the garbage to the point of disposal. Our figures show that approximately seven hours is consumed in actual collection and three hours in transportation. In other words, the collecting vehicle travels ten miles in seven hours and twenty miles in three hours; or during collection it travels at the rate of one and two-fifths miles per hour, and during transportation at the rate of six and two-thirds miles per hour. A motor truck operating under a condition where it only travels ten miles in seven hours is an expensive system; but at the same time, if we were using horses for collection, we could not handle the transportation end of the entire operation. This I believe explains why the motor truck and the horse working in conjunction give the most economical collection.

If now we revert to the two distinct parts of the collecting operation, we immediately see that motive power of widely varying kinds can, under the usual conditions, be operated most economically and the problem therefore reduces itself to some combination that will introduce the advantages of both the horse and the motor truck. This can be done with a vehicle so constructed that it may be pulled by horses and also pulled at motor truck speed. The ability of this vehicle to meet these requirements means that it must have four wheels, must be equipped with rubber tires, must have high speed bearings, must be made out of first class materials and so constructed throughout that it will withstand the speed of the motor truck. The four-wheel trailer seems to fit best into this place and affords a vehicle that makes possible the utilization of the advantages of the horse as well as of the motor truck.

I believe that such trailers drawn by horses during the period of primary collection and by motor truck when transporting the garbage from the collection route to the disposal point are the most economical combination. Any student who is familiar with transportation costs can develop these figures, and if he will do so, he will observe that a first class trailer pulled by horses will collect garbage and refuse from as many points as a horse-drawn wagon at practically the same cost per ton as wagons, and at the same time the cost of transporting the garbage or refuse from the route to the point of disposal will be greatly reduced by using a motor truck.

It is undoubtedly true, however, that the success of this system requires a more finely balanced organization, more attention to details and time factors, than any other system. Routes must be properly worked out over the entire collection area so that tractors can deliver empty trailers and pick up loaded trailers on schedule. Every part of the collection organization must function perfectly if delays are to be avoided. This is possible. I know of one city where the

routes are balanced so that a close schedule is maintained and if there is a delay of more than five minutes by either trailers or tractor at the point of meeting, an investigation is made. Routes must be grouped and their sizes regulated so that collectors can meet at convenient points and the whole organization must function together. If it does not so function, much time will be lost through the delay in picking up the loaded trailers and delivering the empty ones.

It is fundamental to the success of this scheme that the public official in charge of the garbage and refuse collection and his subordinates must be actuated by ideals of efficiency and a desire solely to carry on the operation as it would be carried on by any well managed private corporation. This ideal is not always existent because the stimulating motive of self-interest is sometimes on the other side. However, the ideal is capable of realization and if it is realized, then the costs of collection is less and the service given is better than where collection and transportation are performed with the same motive power.

### Fitchburg Public Works Notes

In the latest report of the commissioner of public works of Fitchburg, Mass., David A. Hartwell, appear several items that may be of interest to officials in other cities.

In referring to sidewalk maintenance, the advantage of more rapidly resurfacing old sidewalks is emphasized, one argument being that "it is more satisfactory to use money on repairs and not on settlement of damage claims"; although no large payments for such claims had been made during the previous year.

Although Fitchburg is not one of the larger cities of the country, its expenses for keeping the main thoroughfares clean of snow reaches a material sum, the average expense each year for the last three having been about \$30,000. During the year prior to the report a Holt 10-ton tractor and Sargent plow were purchased at a cost of about \$8,300, and it was thought probable that some kind of loading machine for removing the snow would be necessary to supplement these, which only pushed it to one side of the roadway.

The collection of ashes and rubbish increases a little each year, the cost recently having been about 45 cents per capita, which is considered very reasonable. This covers the collection of household rubbish and ashes, including store ashes but not commercial rubbish.

Parts of two streets were repaved with the stone blocks with which the street had been paved originally, the blocks being removed to vacant lots and recut to blocks 6 inches to 10 inches long, 3½ to 4½ inches wide and 4½ to 5½ inches deep. The original gravel base was excavated and a cement concrete base 5 inches thick was laid. The recut blocks were laid on this base with a sand bed and the joints filled with cement grout. Four thousand and

twenty-eight square yards of this work on one street cost \$3.48 per square yard, and 8,645 sq. yds. on another street cost \$3.55 per square yard. The cost of recutting the blocks was 74 cents a square yard, which is 51 cents less than similar work had cost a year previous.

In reporting on the water supply, Mr. Hartwell states that, when full, the city's reservoirs have a combined capacity of about 2,000 million gallons and in a series of dry years would theoretically furnish the present consumption; but unfortunately the greatest reserve capacity is connected with the city by a pipe line which

can carry only about one-half of the daily consumption. This condition of course is one which he recommends should be remedied as soon as possible.

The hydrants throughout the city were painted last year, the body of all hydrants being painted yellow, while tops of the low-service hydrants were painted black and those of the high-service hydrants were painted red. The city usually has made contracts for its cast-iron water pipe in December or January at a price \$5 to \$10 less than if the purchase were made during the spring or summer.

# Shockoe Creek Sewer, Richmond, Virginia

**To carry run-off from greatest rainfall in a fifty-year period, to avoid payment of additional damages. Special drain, with automatic pump, for business section. Invert lined with vitrified blocks.**

By George H. Shaw, M.Am. Soc. C.E.

The City of Richmond, Va., is constructing a sewer at the present time to take the flow of Shockoe creek, which, because of its unusually large size, the use of vitrified clay liner plates for lining the invert, and the provision made for disposing of drainage in the central business district during the floods, is of special interest to sewer engineers.

The lower end of Shockoe creek has in recent years been subject to extremely destructive floods. These floods usually occurred during July, August and September and on one occasion the water was four to five feet deep on several of the main streets of the city, with a current as high as eight feet per second, causing over one-half million dollars' worth of damage to property.

The first damage suit, brought in 1915, was carried through the courts and the lower courts awarded damages on the contention that the city was liable because of increased intensity of run-off due to street and sewer improvements further up on the water shed of the creek, which

decision was sustained by the Superior Court of Virginia. Subsequent damage suits were settled out of court and up to the present time nearly one million dollars has been paid for flood damages. These conditions made it imperative that a combined sewer large enough to take the entire stream flow and sewage discharge from the Shockoe creek drainage area be constructed to prevent further property damage.

In preparing the design of the sewer an extensive study of flood flows in Richmond and other cities was made by the Department of Public Works and it was decided to provide for 10,250 c.f.s. as the combined capacity of the double conduits at the lower end of the sewer. This is based on the run-off to be expected from a storm occurring once in 50 years, assuming the water shed of the creek, which is  $11\frac{1}{2}$  square miles in area, completely improved.

Studies of the cross-section of the sewer resulted in the adoption of a reinforced concrete arch section 29'-0" x 16'-3" for the maximum arch section, which is 2,400 feet long; a slightly

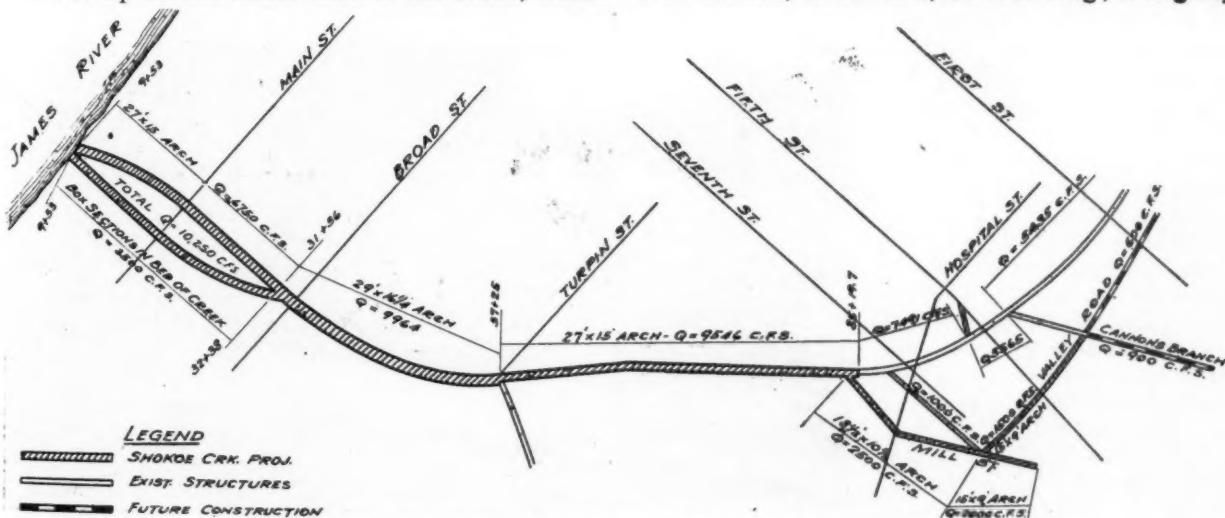
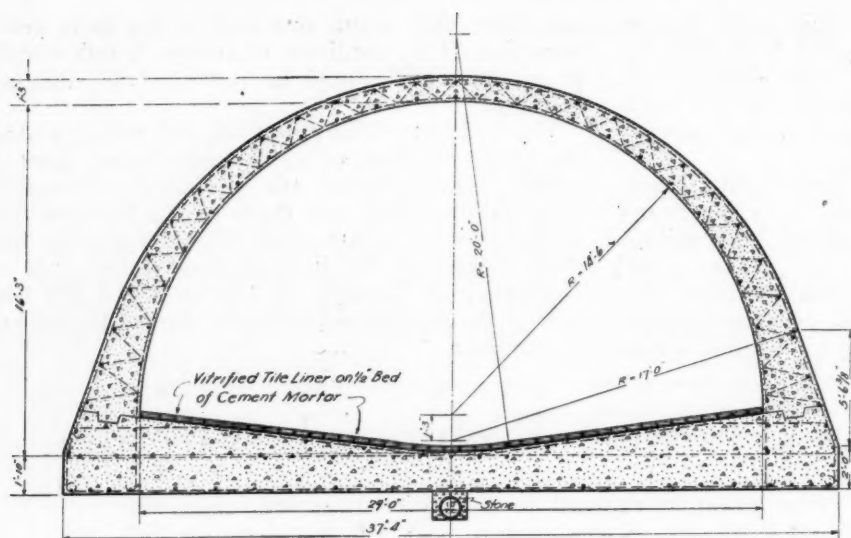


FIG. 1—GENERAL PLAN OF SEWERS IN SHOCKOE CREEK PROJECT



CROSS-SECTION OF 29 FT. BY 16 FT. 3 IN. SEWER

smaller similar section 27' x 15' for 5100 feet, and a similar section 18½ x 10½ feet 1400 feet long for the Mill street section of the sewer. The project also includes 1600 feet of 15' x 9' reinforced concrete arch section and 200 feet of 60" reinforced concrete circular section.

In addition to the above, a box section 17' x 11' 9" to provide for the drainage of the central business section, about 55 acres in extent, is being built. This sewer branches off from the main sewer a short distance below Broad street and extends to the James river, as shown in Figure 1, a distance of 2250 feet. When a flood occurs, gates at both ends of this section are closed and by means of electrically operated pumps the street drainage and sanitary sewage from this low-lying district, where the greatest flood damage occurred, will be pumped over the levee into the river.

It will be noted from the illustration that the reinforced arch section adopted has an invert of greater thickness than is usual in arch sections. This is due to the great width of the sewer compared with its height, made necessary by the restricted available head-room. This results in a large inclined thrust requiring increased invert thickness. The arch is designed for an eccentric loading of 1500 lbs. per sq. ft. and a uniform loading of 2000 lbs. per sq. ft. and provides for the worst conditions than can occur from track loadings when freight yard tracks are laid over it. The arch section was found to offer advantages over a twin box culvert section and to be 15% cheaper, and was therefore adopted.

A feature of special interest is the use of an invert lining of vitrified clay liner plates to give a smooth

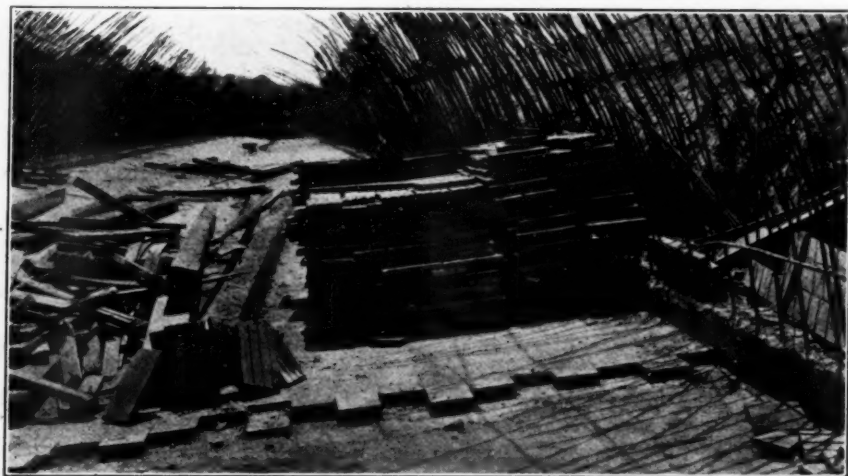
wearing surface and resist erosion. The liner plates used are 9" x 18", 1½" thick, with scorings on the back ¼" in depth to key them into the ½" mortar bed in which they are set. Their use offers the advantages of a material saving in cost and increased smoothness of surface, with ample strength and hardness to resist impact and wear. They were furnished by the Nelsonville Brick Company of Columbus,

In adopting this use of liner plates the engineers took advantage of experience had with such construction in the Penny-

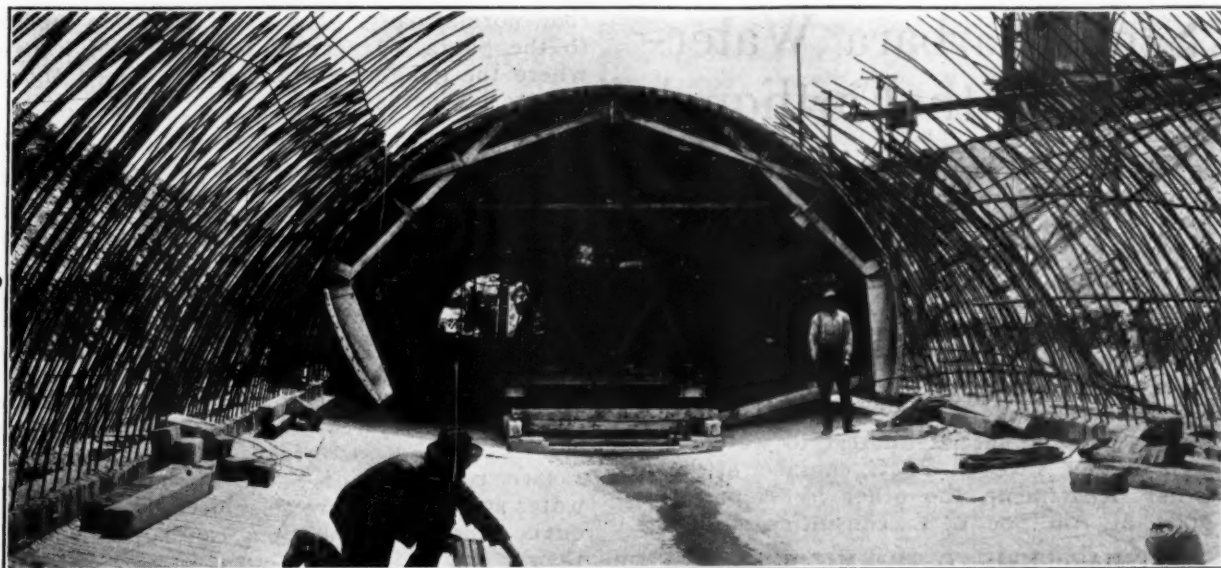
packer Creek interceptor, Philadelphia, Pa., and in the Rutland Road and Dummont Avenue sewers, Brooklyn, N. Y.

The total estimated cost of the sewer is three million dollars. Part of the construction work, amounting to an expenditure of about \$350,000, was done by the city forces; and in August, 1924, contracts for the remainder of the work were awarded in two sections with the requirement that they be completed by January, 1926. Smith Bros., Inc., Dallas, Texas, received the contract for the lower or river end, and Whiting Turner Company, of Baltimore, Md., the contract for the upper end. These contracts involve about 60,000 cubic yards of concrete and five million pounds of reinforcing steel.

Many interesting construction methods are being employed in this job, which have made it possible to advance the work on certain sections considerably faster than contract requirements. An important factor in speeding up the contract work has been the remarkably early removal of forms. During the summer it has been found possible and safe to remove them within 48 hours, and within 72 hours in winter. A 1:2:4 mix is used.



INVERT LINERS PARTLY LAID. PILE OF LINER PLATES AT THE RIGHT



SHOCKOE CREEK SEWER, SHOWING METAL FORM AND LINED INVERT

In conclusion the writer wishes to acknowledge his indebtedness to R. Keith Compton, director of public works, and Thomas T. Towles, assistant director, for courtesies extended to him. The sewer is being built under the direction of Mr. Compton and from contract plans

prepared under the direction of Mr. Towles while he was chief of the bureau of design of the department of Public Works under A. J. Saville, former Director of Public Works. E. P. Asbury is engineer-in-charge of the work, succeeding A. M. Harris, under whose direction the first half of the work was carried on.



MAXIMUM SECTION OF SEWER, COMPLETED AND UNDER CONSTRUCTION. MIXING PLANT AT RIGHT

## Santa Barbara Water-works and the Earthquake

**Effect of the earthquake upon the city's reservoir dams and the distribution system described by engineers.**

The Allied Architects Association of Santa Barbara has published, as a bulletin of the society, a collection of narratives and opinions concerning the earthquake by engineers, architects and others considered especially competent to make such contributions. From these we have selected those of special interest to water works men, one by Alfred R. Poett, engineer of the city water department, the other by Henry Hawgood, M. Am. Soc. C. E., consulting engineer.

### WHAT HAPPENED TO THE MUNICIPAL WATER SYSTEM

By Alfred R. Poett

Damage caused to the distribution system by the earthquake was taken care of by this department as if it were an every-day occurrence.

When the Sheffield dam went out, and breaks occurred in the city distribution mains, crews, under the direction of foremen, who have been with the department for years, were rushed to points where mains were broken, closed gates, and by-passed the water supply to other mains.

Within a half hour of the time Sheffield reservoir was destroyed, Mr. Trace, superintendent of water distribution, had closed the main supply, from Mission tunnel to the reservoir, and by-passed the water supply to reservoirs near the Mission.

Carl Wyant, engineer and superintendent of the Montecito County Water District immediately reported with all the men of his force, and within the space of three days had repaired two sections of the 12-inch distribution main in Sycamore canyon, constructing temporary trestles where the line had been washed out.

The caretaker at Gibraltar dam reported that no breaks or fractures had occurred to the structure. This was confirmed the next day when J. B. Lippincott, consulting engineer for the Water Department, and Victor Trace, superintendent, made a most careful inspection of the dam.

Aside from the destruction of the Sheffield reservoir, and the damage to the distribution main in Sycamore canyon, the distribution system throughout the city was not damaged to any extent.

Work of reconstructing Sheffield reservoir to hold 8 or 10 millions of gallons is progressing rapidly, and several reservoirs of approximately the same capacity are contemplated in different parts of the city, to take care of the outlying districts.

The supply from Mission tunnel was increased 100 per cent, due to the quake, and is now running approximately 750 thousand gallons more

than normal daily. The same condition applies to the Santa Ynez river, north of the Range, where the gauging station near Lompoc shows a material increase.

### RESERVOIR CONSTRUCTION

By Henry Hawgood

The effect of earthquakes on reservoir dams and the earthquake resisting power of different types of dams are matters of more than ordinary importance, particularly so in case of municipal water supplies. Fire invariably springs up in the ruins of an earthquake and the integrity of the water supply becomes vital. Ninety per cent of the damage to San Francisco was due to fire, uncontrollable by reason of shattered water supply.

Two reservoirs of Santa Barbara municipal water supply system were subjected to the earthquake shocks and something can be learned from their behavior.

The Sheffield reservoir, situated within the city limits, of 45,000,000 gallons capacity, had an earth dam of maximum height between 20 and 30 feet, with inner and outer slopes of  $2\frac{1}{2}$  to 1, and crest length of about 700 feet. This dam failed in a curious manner: the central half, pivoting at one end, swung open like a door.

The primary cause of the dam movement was the saturated condition of the base of the outer slope whereby frictional resistance to sliding was reduced to a minimum. It does not appear that any sub-drainage had been provided. The condition was such that it needed but a heavy jar to start the movement and the pressure of the water in the reservoir did the rest. Failures from lack of adequate sub-drainage have not been uncommon.

The second reservoir, known as the Gibraltar, of 15,600 acre feet capacity, the main storage of the supply system, is situated on the Santa Ynez river, reached by a 4-mile tunnel through the intervening mountain range.

Gibraltar dam is an arch structure of concrete of a present height of about 175 feet above stream bed and designed to be carried up 45 feet higher. The radius where now terminated is 243.5 feet and the crest length, 554 feet. The lower half of the dam as constructed is of the full width needed for the ultimate height. At mid height the dam is benched some 8 or 10 feet and carried up on the same slope as the final structure will have. The present top width is 10 feet.

The dam as it stands is a thick arch dam for its lower half, and one of moderate thickness for the upper half.

The chief engineer of the Los Angeles Flood Control District sent an assistant to inspect the dam immediately after the earthquake. His report, which I am permitted to quote, states that there is not a trace of a fracture, large or small, anywhere in the structure, and the quake was very violent in the locality.

The behavior of this arch dam under severe test is a valuable addition to the knowledge of

the subject. It serves to strengthen the growing conviction among engineers that arch dams are safe earthquake structures.

## Normalcy in Chemical Treatment of Sewage\*

**Description of experimental work at South Manchester and conclusions arrived at. Necessity of cooperation in intensive study of effects of chemicals other than precipitation.**

By J. Frederick Jackson

### EXPERIMENTS AT SOUTH MANCHESTER

The greater part of the sewage at South Manchester is the waste water from the silk mills of Cheney Bros. It consists of spent dyes, sulphuric and alum liquors, gums, dextrine, soap and dyes, and concentrated gum suds. Analyses of the samples of the dye liquor, suds from ungumming silk, concentrated dye and dextrine, and dye liquor containing soap gave the following results.

#### Analysis of Component Parts of Waste from Silk Mills at South Manchester

	Dye Liquor	Suds	Dye Dextrine	Dye liquor & soap
Nitrogen .....	05%	0.22%	0.15%	0.01%
Acid (H <sub>2</sub> SO <sub>4</sub> )....	08%	.....	.....	.....
Soap .....	tr	0.05%	.....	1.66%
Free Fat & Silk Gum .....	tr	0.11%	0.14%	0.27%
Dextrine (dextrose) .....	.....	.....	39.08%	.....

#### Analysis of Composite Sample of Waste from Silk Mills at South Manchester

Organic nitrogen .....	590	p.p.m.
Free ammonia .....	2.32	"
Oxygen consumed .....	3,220	"
Total solids .....	36,800	"
Volatile solids .....	14,400	"
Total suspended solids .....	8,400	"
Volatile suspended solids.....	7,000	"
Ether .....	3,986	"
Alkalinity .....	.....	"

These analyses show very complex wastes in which organic matter predominates, and where matters in suspension are largely in colloidal state. Treatment by ordinary biological methods would be very difficult.

At South Manchester, plain sedimentation, agitation with revolving paddles, chemical precipitation, activation and sand filtration were tried.

The highly complex organic character of the sewage and the failure of the biological method of intermittent sand filtration due to the fact that the present beds were noticeably too small to treat the entire flow, led to the experiment of treating the sewage with various chemicals to see if this by itself, if carried far enough, would give an effluent which could be discharged directly into the river; or whether partial chemical treatment before discharge on the sand beds would remove the fatty

acids and silk gum emulsion, the colloidal character of which caused the beds to clog much more quickly than would otherwise be the case. Accordingly, 4,800 gallons per day of the combined sewage was treated by plain sedimentation, continuous flow, using a settling period of 3½ hours.

#### Analysis after Plain Sedimentation

	Raw	Effluent	% Removal
Org. Nit.....	16.1	14.5	10.
Free Amm. ....	5.3	6.0	-13.
Ox. Cons. ....	141.	113.	20.
Total Solids .....	568.	487.	14.
Vol. Solids .....	343.	257.	25.
Total Sus. Solids.....	171.	117.	32.
Vol. Sus. Solids.....	...	...	...
Chlorine .....	49.	47.	...
Alkalinity .....	54.	54.	...

The percentage removal of all constituents was very poor and did not begin to compare with results obtained from plain sedimentation at New Britain.

The sludge was then agitated by revolving paddles and removed as fast as it was formed. This gave only a slight increase in the percentage removal.

The sewage was then treated with lime on the continuous basis, using .2 gr. per litre and a detention period of 4 hours. Good clarification was obtained and the organic nitrogen, oxygen consumed and suspended matter reduced about 33%.

Various laboratory experiments using different combinations of chemicals were made. Using 0.4 gr. lime with 0.2 gr. FeSO<sub>4</sub>; and 0.3 gr. lime with 0.1 gr. alum gave the best results. A much higher percentage removal was obtained in the laboratory experiments than in the continuous process used in the field. Lime and iron and lime and alum in combination with agitation and removal of the sludge was next tried, treating 4,300 gallons of sewage per day. With the lime and iron very good removal of suspended solids was obtained with only slight change in the organic matter.

#### Analysis after Continuous Flow Sedimentation with Lime and Alum

	Raw	Effluent	% Removal
Org. Nit. ....	27.4	20.7	24
Free Amm. ....	12.3	5.9	52
Ox. Cons. ....	175	112	36
Total Solids .....	...	...	...
Vol. Solids .....	...	...	...
Total Sus. Solids .....	169	106	37

#### Agitation and Removal of Sludge after Treatment with Lime and Iron

	Raw	Effluent	% Removal
Org. Nit. ....	20.1	15.3	24.
Free Amm.....	6.3	5.5	13.
Nitrites .....	...	...	...
Nitrates .....	...	...	...
Ox. Cons. ....	160.	134.	16.
Total Solids .....	541.	648.	-20.
Vol. Solids .....	303.	246.	19.
Vol. Sus. Solids.....	211.	192.	9.
Vol. Sus. Solids.....	155.	110.	29.
Chlorine .....	48.	35.	...
Alkalinity .....	58	189.	...
Iron .....	4.3	11.3	-174.

Since the dissolved solids average 330 p.p.m. in the raw sewage and 456 p.p.m. in the effluent, this result was attributed to the solvent action of the lime on the organic matter.

The experiments with lime and alum gave slightly better results and returning the sludge increased the

\*Concluded from page 382

removal of all constituents considerably, even with the use of much smaller quantities of chemicals.

#### Treatment with Lime and Alum

Lime, 1 gm., Alum 5 gm. per liter. Dorr Thickener, 4 hrs. Retention.

	Raw	Effluent	% Removal
Org. Nit. ....	16.2	10.2	37.
Free Amm. ....	7.8	9.5	-12.
Nitrites .....	...	...	...
Nitrates .....	...	...	...
Ox. Cons. ....	130.	79.	39.
Total Solids.....	670.	617.	8.
Vol. Solids .....	362.	150.	59.
Total Sus. Solids ..	130.	70.	46.
Vol. Sus. Solids ....	71.	52.	27.
Chlorine .....	47.	48.	...
Alkalinity .....	56.	120.	...

Lime .05 gm., Alum .2 gm. per liter. Dorr Thickener 4 hrs. Retention Sludge Returned.

	Raw	Effluent	% Removal
Org. Nit. ....	14.9	8.7	42.
Free Amm. ....	6.5	10.7	-65.
Nitrites .....	...	...	...
Nitrates .....	...	...	...
Ox. Cons. ....	154.	73.	53.
Total Solids.....	560.	517.	8.
Vol. Solids .....	307.	150.	51.
Total Sus. Solids....	182.	62.	66.
Vol. Sus. Solids.....	...	...	...
Chlorine .....	53.	58.	...
Alkalinity .....	61.	150.	...

Activated sludge experiments on this sewage were on a small scale and done at the laboratory. The sludge concentration was about 15%, the aeration periods 6 and 15 hours and sufficient air supplied to keep the sludge well agitated. Clarification was good and a very clear effluent obtained in all the tests. The removal of organic matter was practically the same in both periods. No nitrification took place but the dissolved oxygen and relative stability increased with the longer aeration period.

#### Activated Sludge Treatment

	6 hrs. Aeration, 1 hour settling.			15 hrs. Aeration, 1 hour settling.		
	Raw	Effluent	% Removal	Raw	Effluent	% Removal
Org. Nit. ....	16.0	6.4	64.3	18.2	6.5	64.3
Free Amm. ..	8.0	4.4	49.0	5.1	2.6	49.0
Nitrites .....	...	...	...	...	...	...
Nitrates .....	6	3	...	17.	3	...
Ox. Cons.....	116.	49.	57.7	145.	40.	72.4

The treatment of composites of the concentrated wastes consisted in first filtering, second liming and filtering a sample of the frisson gum suds, acid gum suds and dyes, alkali soap and dyes, gambier, logwood, alum and iron. Filtering was assumed to give the effect of sedimentation. By filtering alone fairly high removals of organic matter and total solids were obtained, suspended solids were entirely removed but there still remained 28,000 p.p.m. of dissolved solids. Liming and then filtering did not

#### Treatment of Composite Wastes

	Untreated p.p.m.	Filtered p.p.m.	By Filtration Per Cent	Limed and Filtered	By Liming and Filtration Per Cent
Org. Nit. ....	590	160	72.9	144	75.5
Nit. as Free Am.	2.32	1.44	38.0	1.00	56.9
Ox. Cons.....	3,200	1,260	60.6	656	79.5
<b>Solids</b>					
Total .....	36,800	28,000	23.9	27,000	27.2
Volatile .....	14,400	8,200	43.0	3,200	77.7
Total Sus.....	8,400	0	100	0	100
Volatile .....	7,000	0	100	0	100
Ether Extract..	3,986	500	87.7	50	98.7

affect the results materially except the oxygen consumed and the ether extract where the reduction was very noticeable. Treating the composite with an excess of sulphuric acid speeded up the precipitation but upon dilution the supernatant liquor was very turbid, yellow and colloidal in character. The supernatant liquor after using an excess of lime was very clear and remained unchanged when diluted.

#### SUMMARY

With the combined sewage at South Manchester, chemical treatment alone had a marked effect on certain constituents and on others practically none. In combination with agitation of the sludge, and particularly where the sludge was returned, the removals were higher. It is interesting to note that when activated sludge was introduced, or the sludge returned from the thickener, there was improvement in the character of the effluent.

The results obtained from treatment of the concentrated wastes by chemicals were quite promising but the experiments were not carried far enough to permit drawing definite conclusions from them. They did, however, emphasize the advisability of further experimentation in treatment of wastes of this character by segregation and chemicals.

#### CONCLUSIONS

While precipitation seems to be the major effect of chemical treatment, further studies may reveal other reactions which would be of considerable value. The apparent confusion in relation to the chemical treatment of sewage seems to have originated in the tendency to study the precipitating effect of the chemicals to the neglect of their action as solvents and germicides. But, granting the importance of the precipitation phase, investigators have not as yet given such study to it as would warrant discarding it as an effective and useful process in sewage treatment.

The use of chemicals has been in the nature of mass treatment. Most of the work was done by engineers or by chemists who had taken up sanitary engineering. The effect of any one compound was masked by physical conditions and variations in type of mechanical equipment. No particular effort seems to have been made to harmonize these or to study intensively the reactions taking place with individual compounds. The refinement of measurements and the ingenuity in perfecting devices for application of chemicals and control of processes so noticeable with water purification appear to have been neglected in sewage treatment. Methods of reporting results have differed so widely that true comparison between work of different processes in treating different sewages has been difficult.

Investigators of sewage treatment have heretofore been working independently of each other. Much progress has been made and some very brilliant individual work done. The time has now come for closer association of investigators. The solution of the problem can be assisted and hastened materially by cooperation.

To secure this there might be created a joint committee composed of sanitary, mechanical and electrical engineers, chemists, physicists, bacteriologists and microscopists who would review the work al-

ready accomplished, each attempting to correlate his work with the others, and combine all in such a way as to utilize the best features of each. This would be followed by combined experimentation to secure a practical solution of the problem.

## Sewage Treatment in Fitchburg

A description of the Fitchburg, Mass., sewage treatment plant and articles dealing with its operation have appeared from time to time in PUBLIC WORKS during the past ten years, and operation last year was apparently up to the high standard of this plant. Some of the changes made in construction and in the more significant features of the plant operation are referred to below.

It had been found that the sludge in the hopper bottoms of the Imhoff tanks did not slide automatically to the foot of the sludge pipe as satisfactorily as could be desired, partly owing to fine sand or mineral matter that is carried by the sewage into the tanks. To remedy this condition, piping was installed in one tank which, when connected by fire hose with a water supply hydrant, agitates the sludge and causes it to slide more rapidly. This installation greatly improved conditions in that tank and it was thought probable that similar piping would be placed in the other four tanks. As stated in the report, piping of this kind is quite generally installed in Imhoff tanks that have been constructed in recent years.

Removal of settleable solids, as shown by the conical measuring glass tests, averaged 98.67 per cent. for the year, with only an occasional readable volume of settled solids in the Imhoff tank effluent after standing two hours. The settleable solids pass readily into the digestion chambers and the surface of the tanks was free at all time from floating gas-lifted solids. There was practically no foaming at any time during the year, although slight indications of it have been noted at times when a marked increase in sewage flow took place. Sludge level was kept down to an average of three to four feet below the slots. The sludge drawn was in all cases well digested and contained a larger percentage of solids than for several years previous.

The temperature of the digesting sludge was taken at frequent intervals during the spring, summer and fall. The temperature readings were taken at a point seven feet below the slots or about 3.7 feet above the extreme bottom of the hoppers. Corresponding temperatures of air and crude sewage were taken at the same time.

The temperature of the sludge continued low (43 degrees F.) until about the first of April, after which it gradually increased, reaching a maximum of 65 degrees on August 4th. It remained above 60 degrees until October 1st, after

which it fell during the next two months to 49 degrees. That some digestion was taking place even at the low temperatures of winter was evidenced by bubbles of gas appearing in the chimneys. The digestion was much more active, however, during the period of higher temperatures from May to November inclusive. All of the sludge drawn was well digested and free from all odor except the tarry smell characteristic of well-digested sludge.

In cooperation with the New Jersey Agricultural Experiment Station, tests were made during the latter half of the year to determine the hydrogenion concentration or true acidity of the sewage and effluents in 24 hour composite samples kept on ice. From a table of these temperatures it appears that there was comparatively little difference in pH between the sewage and effluents, although the pH of the final effluent from the secondary tanks was consistently a little lower than that of the Imhoff tank effluent. The average pH of the sewage was 6.6, that of the Imhoff tank effluent the same, and that of the final effluent 6.0. The pH of the sewage and tank effluents varied during the period of the investigation from a minimum of 5.4 to a maximum of 7.1 in the case of sewage and 7.2 in the case of tank effluent. The pH of the final effluent varied from a minimum of 5.2 to a maximum of 6.5. All pH readings showed a marked increase during the summer. Concentration of the sewage may have been a factor in this. Favorable sludge digestion was taking place throughout the period. It was believed by the chemist of the plant, Herbert B. Allen, that similar tests of the sludge liquor would be of more value as indicating the kind and extent of sludge digestion taking place. The final effluent, he reports, has been stable practically every day for the last ten years. The nitrification obtained last year was the highest of any year since the plant was put in operation.

## Street Lighting in Pasadena

Pasadena, California, is said to have at present the best illuminated street west of Chicago. A new lighting system has just been completed on East Green St., along with other improvements, the total cost of which for 7,450 feet of improvement was more than one million dollars.

The lighting units used are of the latest type manufactured by the Westinghouse Electric and Manufacturing Co. The standards are the "Arcadia" type of cast iron painted a bronze color and surmounted by a solid bronze octagonal lantern, equipped with a Bi-lux reflector and utilizing a single 600 c. p. street lamp. The reflector reflects the light beam at an angle of  $22\frac{1}{2}$  degrees with the curb, giving an illumination intensity of 2,000 c. p. up and down the street, 500 c. p. directly in front of the post and only 300 c. p. at the rear of the post toward the property line.

The standards are placed 2 feet from the face of the curb at intervals of 115 feet, staggered. The street is 48 feet wide between curbs and 70 feet

between property lines. At three intersections four posts are placed 15 feet back from the intersecting street, giving an average spacing of 90 feet between lights at the intersections.

The wires are carried underground, as are all other wires and utilities of this street improvement. The power and lighting conduits were placed at an average depth of 3 feet below the surface of the

roadway, all conduits being enclosed in lead to give adequate protection against moisture. Each post is equipped with a safety coil and a disconnecting pot-head at the base standard.

The lighting system was designed by E. L. Bettanier, engineer of the Municipal Light and Power Co., assisted by C. E. Johnson, engineer of the Westinghouse Co.

## Effect of Six-wheel Trucks on Pavements

**Tensile stress about half as great as that produced by a four-wheel truck of the same gross load, practically independent of axle spacing; maximum stress occurs in bottom of slab and along edge of slab; and fiber deformation is twice as great when outer wheel is 9 inches from the edge as when 21 inches.**

To provide a vehicle which can carry heavy pay loads without violating the regulations of the various states that limit axle load, wheel load, and load per inch width of tire, manufacturers of vehicles have designed the six-wheel truck, which carries the bulk of the load on four rear wheels instead of two, thus doubling the legal capacity of the vehicle.

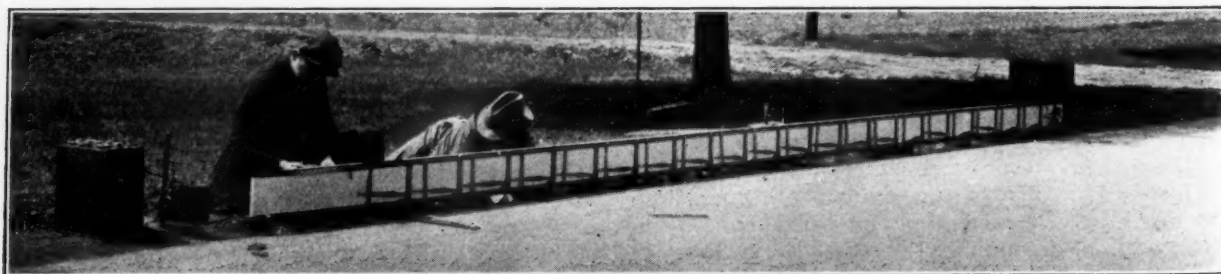
What the actual effect of this greater load will be upon highway pavements has been studied experimentally by the Bureau of Public Roads. Briefly, these "indicate definitely that the tensile stress set up in a concrete pavement by a six-wheel truck is only about half as great as the stress produced by a four-wheel truck of the same gross load." The tests and conclusions therefrom are described by L. W. Teller, associate engineer of tests with the U. S. Bureau of Public Roads, in the October issue of the journal of that bureau.

The principal objects of the tests were to determine:

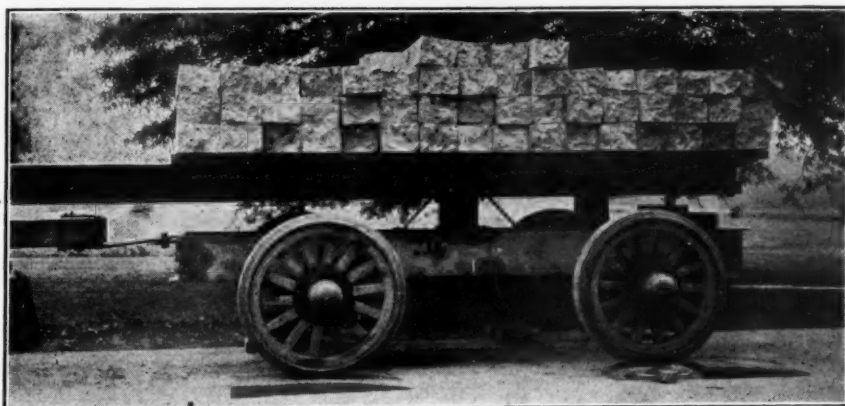
1. The relative stresses produced in the pavement by four and six-wheel vehicles having (a) the same gross load, and (b) the same wheel load.
2. The effect of the axle spacing of six-wheel vehicles on the stress produced in the pavement.

In order to study the effect of various axle spacings, a special trailer was constructed consisting of a frame provided with two axles, which could be spaced at any distance from 3 to 10 feet apart, the load being equally supported by all four wheels. The front end of the platform that carried the cargo rested on a knife-edge placed transversely on the rear end of the motor truck which was used to move the trailer. Thus the essentials of a six-wheel vehicle were reproduced and axle spacings of from 3 to 10 feet could be had at will. As the trailer was to be run only at very low speeds over a smooth pavement, no springs were provided. The wheels were equipped with 40 by 6 inch single solid rubber truck tires. A four-wheel, 5-ton capacity truck, equipped with similar tires, was used for comparative tests. In addition to the equipment described above, two other trucks were used, one a six-wheel and one a four-wheel class B Army truck of identical design except for the rear end construction, both equipped with pneumatic tires.

Two "loadometers" were used to measure the wheel loads, these devices having been calibrated prior to their use in this investigation. The vehicle being weighed was supported in a level position by small wheel platforms.



GENERAL VIEW OF DEFLECTOMETER USED IN TESTS OF SIX-WHEEL TRUCKS.



SPECIAL TRAILER WITH 86-INCH AXLE SPACING.  
The rear wheels are resting on the loadometers, the front wheels on the leveling platforms.

The test pavement was a 6-inch plain concrete slab of uniform cross section, 18 feet wide and 30 feet between transverse joints. The tests were made at one corner of this slab, the transverse joint being a poured joint, without expansion material.

The deflection data were secured with an instrument called a "deflectometer," which consists of a series of pen arms supported by the pavement. Each pen arm traces on a moving paper a continuous record of the deflection of the slab at that point as the truck wheel moves over the slab. Thus, each curve is an influence line of deflection for the particular point at which the pen arm is supported. The vertical movement of the slab is multiplied fifty times on these curves by a direct lever action. The apparatus is provided with electric contacts which record on the same paper the instant at which the truck passes a given point. From a series of such curves it is possible to obtain the elastic curve of the pavement for any position of the wheel. The speed of the truck and of the paper are determined by a pendulum of known period. Graphic strain gauges were installed along the upper and lower edges of the slab and recorded the maximum compressive and tensile deformations occurring in the outer fibers of the pavement as the truck passed.

Part of the test runs were made with the outer wheels centered over a line painted 9 inches from the edge and part over a line 21 inches from the edge. Complete data were obtained on nearly 100 runs, under the following conditions:

I. Four-wheel trucks:

(a) Pneumatic tires, 44 by 10 inches, 9 inches from edge of pavement.

1. 4,000-pound wheel load.

2. 8,000-pound wheel load.

(b) Single solid tires, 40 by 6 inches, 9 and 21 inches

from edge of pavement, with 4,000, 5,000, 6,000, 7,000, and 8,000-pound wheel loads.

II. Six-wheel trucks:

(a) Pneumatic tires, 38 by 9 inches, with 50-inch axle spacing, 9 inches from edge of pavement.

1. 4,000-pound wheel load.

2. 4,300-pound wheel load.

(b) Pneumatic tires, 40 by 6 inches, with 4,350-pound wheel load.

1. Nine inches from edge of pavement and 36, 40, 44, 48, 54, 60, 72, 86, and 118 inch axle spacings.

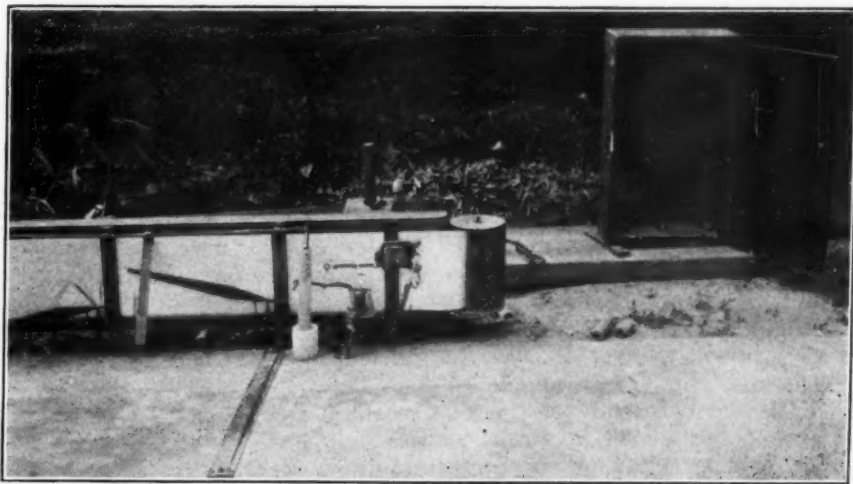
2. Twenty-one inches from edge of pavement and 36, 40, 44, and 54 inch axle spacings.

By means of records of the deflection of each of several points in the slab as the truck approached, passed and receded from it, it was possible to determine the form assumed by the pavement under the load or the elastic curve of the pavement. Such curves are shown in the illustrations for four-wheel and six-wheel trucks.

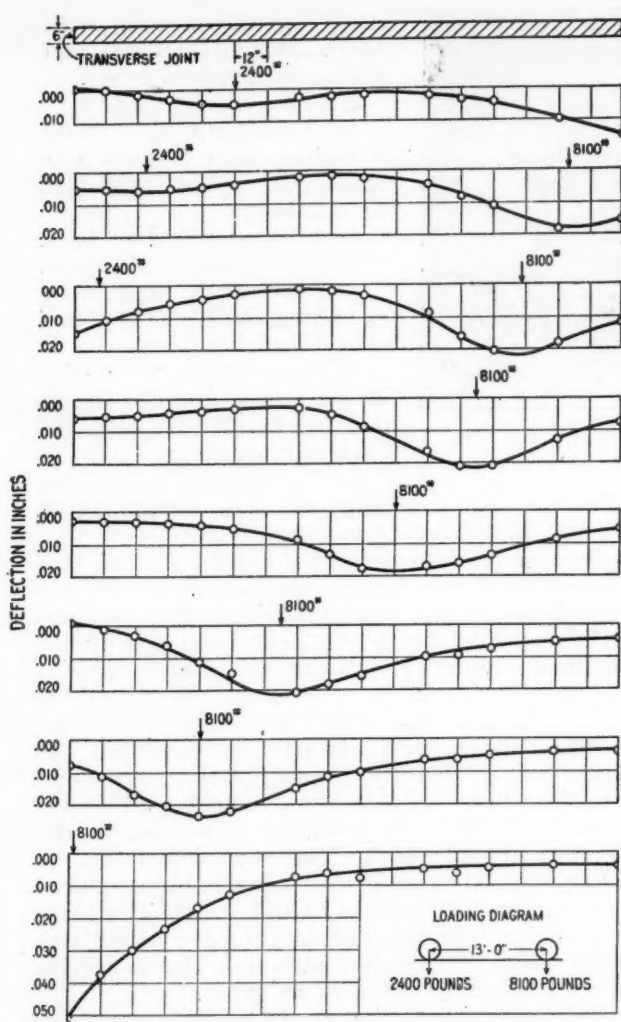
From these curves it will be seen that the deflection is directly proportional to the load. For instance, a 2,400-pound wheel load at the corner of the slab produced a maximum deflection of 0.015 inch. The rear wheel load of 8,100 pounds passing the same point produced a maximum deflection of 0.051 inch. The same is true for deflections along the edge of the slab away from the corner, although the deflection is only about 40 per cent as great.

The data from the strain gauges consisted of graphic records showing the maximum tensile and compressive deformations occurring at the gauge position for each load application. These records in each case were reduced to the maximum unit deformation.

Examining the data from all of the runs with the various vehicles, the stress produced along the edge of the pavement by a wheel load 21



DETAILS OF PENDULUM (AT RIGHT IN BOX) AND ROAD CONTACTS OF DEFLECTOMETER.



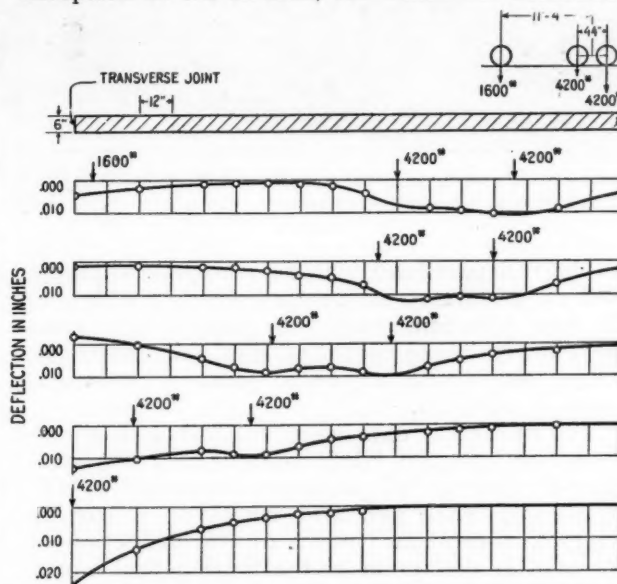
ELASTIC CURVES OF 6-INCH CONCRETE PAVEMENT UNDER 4-WHEEL TRUCK IN VARIOUS POSITIONS.

inches from the edge is found to be 47 per cent. of that produced by the same load 9 inches from the edge. This percentage varied from 43 to 51 per cent. for the various groups of comparable results.

The variation in stress along the edge of the pavement for a given load is shown by the diagram which shows the maximum edge stresses at the several points resulting from the load as it passes along the edge. The significance of these diagrams lies in the fact that they show that for six-wheel trucks the maximum tensile stress occurs in the bottom of the slab regardless of the axle spacing. This means that, even though there is counterflexure of the pavement between the wheels, the tension developed in the top of the slab is of less magnitude than the tension developed in the bottom of the slab directly under the wheels. This latter tension, then, is the critical stress for the six-wheel as well as the four-wheel vehicle.

This leads to a study of the relative fiber deformations produced by four-wheel and six-wheel vehicles, having, first, the same gross loads, and, second, the same wheel loads. The difference between the two four-wheel trucks

was only in the area of contact between the tire and the pavement due to the type of tire, and it is obvious that this has no appreciable effect on the stress. The data indicate that for a given gross load the six-wheel truck will cause only about one-half the tensile deformation produced by the four-wheel truck. This seems to be true for all axle spacings with the possible exception of the 36-inch, for which the recorded



ELASTIC CURVES OF 6-INCH CONCRETE PAVEMENT UNDER 6-WHEEL TRUCK IN VARIOUS POSITIONS.

deformation is slightly greater. This may be due to some peculiarity of this particular test, although it seems more probable that with wheels but 36 inches apart the condition is beginning to approach that of a concentrated load. However, as it is doubtful if such a close axle spacing will be met in practice, this small increased stress would not appear to be important. The significant indication is that the stress in the pavement produced by a six-wheel truck is a function of the wheel load and not of the axle spacing.

#### CONCLUSIONS FROM INVESTIGATION

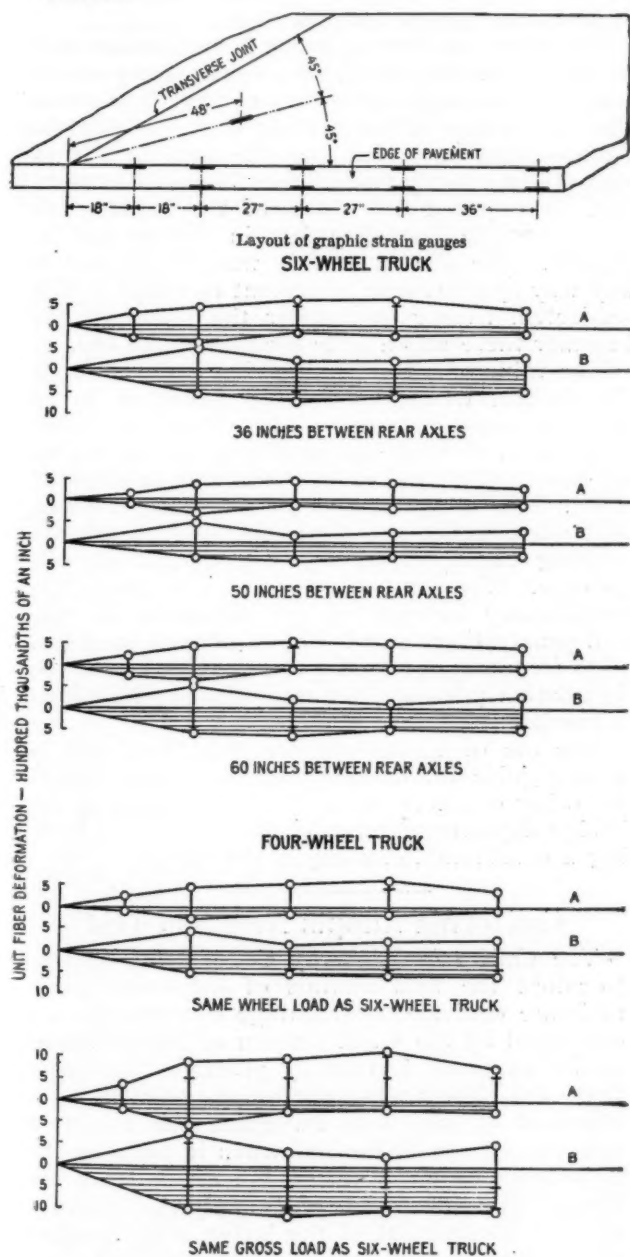
Summing up, the following may be stated as the indications of this investigation:

1. The deflection of a concrete pavement is directly proportional to the load applied (within the limits of this investigation).
2. A load passing along the test pavement (uniform thickness, 6 inches) 9 inches from the edge of the pavement produced approximately twice the fiber deformation in the edge of the pavement that was caused by the same load passing along a path 21 inches from the edge.
3. The tension produced in the top of a pavement due to counterflexure between the wheels of a six-wheel vehicle is less than the tension produced in the bottom of the pavement directly under the wheel, regardless of the axle spacing.
4. In the case of six-wheel vehicles the maximum tension produced in the pavements seems

to be a function of the wheel load and not of the axle spacing, at least between the limits of 3 feet and 10 feet.

5. Within the deformation limits obtained in this investigation (maximum unit fiber deformation of about 0.0001 inch per inch) the fiber deformation in the pavement is directly proportional to the load.

6. In a pavement slab of uniform thickness the maximum deformation occurs along the edge of the slab for both four-wheel and six-wheel vehicles.



VARIATION IN STRESS ALONG EDGE OF PAVEMENT RESULTING FROM PASSAGE OF 6-WHEEL AND 4-WHEEL TRUCKS.

The stresses indicated are the maxima produced at the several points by the loads in any position.

## Preparing Concrete Cores for Compression Tests

In preparing concrete cores for compression tests, methods and procedure have been developed by the Division of Tests of the Bureau of Public Roads that seem to give the most reliable results of any that have been employed, and which are recommended for general adoption.

It has been found that capping the cores with neat cement is the most satisfactory method, whether the ends of the core are very irregular or not. Plaster of Paris has been used with success where the specimens had especially smooth end surfaces, but in general this practice is not advised. It has been found from comparative tests that cores capped with plaster of Paris may show a reduction in strength as great as 50 per cent below those similar in character capped with Portland cement.

The method adopted in the laboratory of the Bureau of Public Roads is to remove any very sharp or abnormal projections from the end of the core by means of a carborundum saw or the skillful use of a hammer, after which the surface is cleaned with hydrochloric acid, followed by rinsing with a jet of water. Unless this cleansing process is carefully done the cap will not adhere to the core. No attempt should be made to prepare specimens with heights equal to or exactly twice their diameters. It has been found that more accurate results are obtained when the original core is capped and tested without any attempt to build up its height with the capping material. The necessary correction for height may easily be made by applying the correction factor given in A. S. T. M. Tentative Standard Method of Securing Specimens of Hardened Concrete from a Structure, serial designation C45—21T.

The surface to be capped is thoroughly brushed with a soft paste of neat cement in order to insure a good bond for the cap. The specimen should be kept wet at all times, and a minimum period of time should elapse between the various operations in order to prevent premature drying of the unhydrated cement in the cap. Several methods of applying the cap may be followed, depending upon the irregularities of the surface. If the end of the core is comparatively smooth neat cement paste of approximately normal consistency is heaped upon the specimen and the latter then inverted onto a piece of plate glass which has been oiled and is free from scratches. New plate glass is recommended, as any scratches or roughness may cause the cement to stick to the glass, thereby removing the cap from the core. The excess cement is squeezed out by pressing the core firmly down against the plate, and a trowel is used to point up the cement around the edges of the core. Care should be taken that the axis of the specimen is perpendicular to the glass surface.

Another method which is used in the case of specimens having irregular ends consists of wrapping a piece of thin sheet metal, which has been oiled, around the core so as to form a mold. This may be held in place with several wire bands. The highest point of the end of the core should be flush with the end of this mold, so that when the cement paste is applied there will be neither an excessive thickness of cap nor any projection from the core. The form thus prepared is filled with cement paste, after which a piece of oiled plate glass is placed upon it so as to form a plane bearing surface.

The selection of oil in these operations is important, as some oil seems to lack those qualities which prevent adhesion of the cement to the glass or metal surfaces. Several brands should be tried for the purpose of selecting that which gives the best results. Mobiloil B and tractor crank-case oil have been used in the bureau's laboratory with satisfaction.

Lumnite cement, either as a stiff paste or in a 1 : 1 mortar mixture, should give satisfactory results if sufficient care is taken to supply all the water required for its hydration. When Lumnite cement is used the freshly capped specimens should be kept in a moist closet or thoroughly surrounded by saturated burlap bags for at least 12 hours. If the initial curing is done properly, cores capped with Lumnite cement may be tested 24 hours after capping. Portland cement paste gives satisfactory results, especially if a 4 per cent solution of calcium chloride is used as the mixing water. This accelerates the hardening of the cement sufficiently to allow a compression test to be made after three days of curing.

The chief requisites of a material suitable for capping specimens are that its strength at the time of the test shall be at least equal to that of the specimen and that the modulus of elasticity shall be as nearly that of the concrete under test as it is feasible to obtain.

### Driving Concrete Pile Twenty-four Hours Old

The bulletin of the California Highway Commission for October contains a description by Harlan D. Miller, bridge engineer of the commission, of an interesting test of a pile made of Lumnite cement concrete. Mr. Miller's article is as follows:

An interesting test, which may prove of great value in reinforced concrete pile foundation construction, has just been completed by the bridge department at Pismo, San Luis Obispo county, where two state highway bridges are under construction. A concrete "test" pile was cast using Lumnite cement instead of ordinary portland cement. Twenty-four hours after the pile was cast it was driven forty-five feet in the ground to refusal. The test was one of the first made by the California Highway Commission with this special cement.

In this instance Lumnite cement seems to have developed, at twenty-four hours, a greater

strength than most portland cements at twenty-eight days.

It was not possible to have made a strength test of the concrete used in the pile at the age of twenty-four hours, but two 6 x 12-inch sample cylinders of the concrete were tested within forty-eight hours after casting. The 200,000-pound state testing machine did not break either of the test samples, indicating a strength in excess of 5,600 pounds per square inch. This test concrete, after forty-eight hours, had a strength at least equal to ordinary portland cement concrete at an age of three months.

A number one Vulcan steam hammer was used to drive the test pile, which was forty-seven feet long and eighteen inches square. The usual time of curing before driving concrete piles is twenty-eight days, but the pile used at Pismo was driven exactly twenty-four hours after casting. It required 643 blows of the hammer to drive the pile forty-five feet in the ground to refusal. The pile apparently was not injured in any way by the rough treatment to which it was subjected, except that under the blows of the hammer there was a little spalling at the top.

The value of a test of this kind is obvious. In the future, whenever concrete piling is to be used in the construction of bridges or other structures, a "test" concrete pile can be driven on short notice and exact conditions determined upon. This is not always possible with wooden test piles, which are generally used to obviate waiting twenty-eight days for a concrete pile to cure. Wooden test piles are sometimes unsatisfactory because of the difference in size and penetrating power. The driving of such test piles frequently gives the wrong impression, and foundation piles are cast an improper length as a result.

The use of a concrete pile as a "test" pile is a true guide for determining the proper length for other concrete piles. This experiment of the bridge department may be the means of effecting a considerable saving in the future.

### California Adopts New Soil Test

The California Highway Commission expects to adopt the field method of determining the moisture equivalent percentage of subgrade soil developed by the U. S. Bureau of Public Roads as its standard laboratory practice. In order that the laboratory operators may have a standard by which to recognize the condition and appearance of the soil when it contains the moisture equivalent percentage of moisture the Bureau of Public Roads will supply the Commission, at the request of the latter, with samples of soil the moisture equivalent of which has been determined by the standard centrifuge method. These samples, when wetted with the known moisture equivalent percentage of moisture, will provide a gauge by which the appearance of a soil when it reaches the critical stage can be determined. The Bureau will gladly perform a similar service for any other laboratories that may be desirous of employing the new test.

# PUBLIC WORKS

Published Monthly  
at 243 W. 39th St., New York, N. Y.

A. W. HUME, President J. T. MORRIS, Treasurer

Subscription Rates  
United States and Possessions, Mexico and Cuba \$2.00 year  
All other countries ..... \$4.00 year  
Single copies, 35 cents each

Change of Address  
Subscribers are requested to notify us promptly of change of address, giving both old and new addresses.

Telephone (New York): Pennsylvania 4390  
Western Office: Monadnock Block, Chicago  
A. PRESCOTT FOLWELL, Editor

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### The A. S. M. I.

The American Society for Municipal Improvements is the only national organization with a membership composed exclusively of engineers and public officials connected more or less directly with municipal improvements, and the only one which specializes in the engineering and construction features of street paving and sewerage. Both the American Society of Civil Engineers and the American Public Health Association have sanitary engineering divisions, and the

former a highway division; but these play only a minor part in the functioning of those societies.

This being the case, the A. S. M. I. should embrace in its membership all municipal officials and technical employees who are connected with the several departments or bureaus having charge of constructing or maintaining streets, sewers, water works, street lighting, and refuse collection and disposal; and as associate members all who are interested in furnishing materials to such departments. But it falls far short of this. While the membership should be three or four thousand, it is only about 650, and has been decreasing for three years past.

But there are indications that an increase in activity and membership is at hand. The executive committee realizes the critical state of affairs and at the convention last month took a step which is expected to give results. It employed a secretary who will devote a large part of his time to the society's affairs and who has had experience in this class of work. Heretofore the secretary has been an engineer who gave to the society's affairs what time he could spare from his regular work, and was paid about enough to compensate him for the services he rendered at the annual convention only. All friends of the society will extend to the new secretary their best wishes and active cooperation.

About fifteen years ago another national organization, the American Water Works Association, had about the same membership as that of the A. S. M. I., and five years later it also was losing members. But today it has passed the two thousand mark and is trying to attain a goal of 2,500 by next year's convention. Twenty years ago the A. S. M. I. had less than one hundred members and had been losing. It then took a spurt to two or three times this number and rested on its oars. About ten years ago it practically doubled its membership, and again became sluggish. Here's hoping that the present re-awakening will carry the number of members well up toward two thousand, with all that this involves of more intensive and extensive service to its members and to the whole broad field of municipal public works.

### Day Labor vs. Contract on Public Work

The Associated General Contractors of America, or at least those who are directing the activities of that society, are thoroughly aroused on the subject of the construction of public works by day labor instead of by contract. "The Constructor," the official monthly publication of the society, and the "Members' News Letter," its bi-weekly bulletin, have for the past year devoted a considerable part of each issue to discussions and figures offering arguments against day labor.

Probably few if any contractors and not many engineers will deny the general statement that work can be done more cheaply by a skilled contractor than by a public official employing day

labor. Many engineers, however, believe that day labor work is justified under certain conditions, such as the existence of known or suspected collusion among bidders, work to be done under unknown or unusually hazardous conditions or in which changes of plans will probably be necessary as the work proceeds, or where it is of such a nature that serious consequence would result from carelessness or dishonesty which it would be difficult to detect. (Probably the contractors themselves would offer little objection to day labor construction of small jobs occurring repeatedly throughout the year, such as the laying of short extensions of water pipes or sewers by regular employees of city departments.)

Most of the above exceptions can be met by other alternatives, however. If collusion is suspected, announcement of that fact and a call for new bids will often secure reasonable figures from former bidders or serve to bring in bids from new ones. Where the work involves unknown or unusually hazardous conditions or probable change of plans, the construction of all or part of it by a responsible contractor under the cost plus system will generally prove satisfactory. In the latter case a list of responsible contractors should (in our opinion, if the local laws permit) be selected beforehand, and only selected contractors be allowed to bid; the questionnaire recently prepared for this purpose by the "Joint Conference on Constructional Practices" being perhaps used as a basis of selection.

There would seem to be undeniable merit in the argument that a contractor possessing "skill, integrity and responsibility," and experienced in the kind of work contemplated, would almost always be able to perform such work more satisfactorily and at less cost than would an engineer who has not made contracting a profession and who has no financial interest at stake in keeping down costs.

The arguments from the point of view of the contractor were presented last month before the American Society for Municipal Improvements by J. H. Ellison and his paper is published elsewhere in this issue as being probably the best statement that has been made within the limits of a single article.

### Material Liens in Texas

The recent legislature in Texas passed a lien law "to create a lien in favor of any person, firm or corporation who may furnish any material, apparatus, fixtures, machinery or labor, to contractors who contract for public improvements." This gives a lien "on the moneys, or bonds, or warrants, due or to become due to such contractor for such improvements." If an official is notified in writing, he must retain enough of any amount due the contractor to pay the claim if it shall be established by law. "The fact that—machinery people lose enormous amounts of money by such contractors leaving their jobs incomplete and making away with the machinery

creates an emergency and an imperative public necessity that the rules requiring bills to be read on three several occasions be suspended, and that this law take effect from and after its passage."

Are the contractors in Texas as bad as all that?

### Gravel Roads in Nevada

Owing to financial limitations and physical conditions the chief type of road constructed in Nevada is gravel surface. At first the results obtained were not very satisfactory and all sorts of experiments were tried out, such as requiring sprinkling and rolling, but in spite of this the surfaces would soon loosen up. It was found, after two or three years of experimenting, that the only satisfactory manner of securing a compacted surface was to accept a job in loose condition, releasing the contractor; following which the state would, by force account, secure a properly compacted surface during the following winter season by means of the judicious use of road drags and scrapers and the compacting effect of the travel using the road. The surfaces now being obtained by this method are highly satisfactory, are obtained at a minimum cost, and by means of proper and constant attention are costing a minimum for maintenance.

As has been the experience in other states. Nevada's gravel roads are found to form corrugations. Concerning this, the state highway engineer in his latest report makes the following statement:

While it is not possible to totally prevent the formation of corrugations in gravel-surfaced roads, they can be eliminated to a large extent. This can be brought about by the use of small angular-shaped particles of gravel instead of the highly rounded particles for surfacing material.

To provide such a surfacing material in Nevada it is necessary to crush pit-run gravel and to use only the material that ranges in size from one inch down and to reject practically all of the clay and silt occurring as fines in the pit-run material and to retain only those fines produced by crushing. The removal of the clay and the silt from the gravel eliminates one of the greatest contributory factors to the development of corrugations. The setting of the roadway surface is somewhat retarded by the removal of clay, and considerable attention must be devoted to the compaction of the gravel. Eventually, however, a far better and more lasting surface is obtained. The greater portion of the gravel-surfaced roads constructed in Nevada the past two years have been surfaced with crushed gravel and compacted without an appreciable amount of clay or silt. The corrugations are much slower in developing and more easily eliminated by maintenance on these projects than on the other projects where the surface was merely pit-run gravel.

To maintain a comparatively smooth surface on the project constructed of crushed gravel, it is only necessary to drag the surface at regular intervals, regardless of rainfall or other conditions, and to keep a thin covering of loose material brushed over the road by means of drags. The amount of maintenance required depends, of course, largely upon the amount of traffic, for, after a certain volume of traffic dragging will not keep the road free from corrugation. The corrugations can, however, be cut down and the surface materials rearranged and distributed with a road planer. This road planer is a combination of short blades working at opposite angles and a sacrifier made up of small teeth that comb and cut down the ridges. The road planer works very satisfactorily on roads where the maximum size of surfacing gravel is not more than one inch in size.

## Day Labor in Public Construction\*

**Arguments against the practice from the point of view of the contractor, presented by an officer of the Associated General Contractors of America. Government should not compete with private business. Day labor more expensive to taxpayers than contract work. Declaration of Hennepin County Taxpayers' Association.**

By J. H. Ellison†

Following the time-honored custom of the preacher, it has seemed to the writer advisable to begin with a "text." The text is multiple in character and appears to afford a reasonable foundation for what he has to offer.

*Extract from the "Platform of the Republican Party" adopted by the National Republican Convention—Cleveland, 1924.*

"The prosperity of the American Nation rests on the vigor of private initiative which has bred a spirit of independence and self-reliance. The Republican Party stands now, as always, against all attempts to put the Government into business. American industry should not be compelled to struggle against Government competition."

*Extract from the "Democratic Platform" adopted by the Democratic National Convention—New York, 1924.*

"We oppose the extension of bureaucracy, the creation of unnecessary bureaus and federal agencies and the multiplication of offices and officeholders."

*Extract from President Coolidge's address of acceptance, August, 1924:*

"I favor the American system of individual enterprise, and I am opposed to any general extension of government ownership and control."

*Extract from President Coolidge's address at exercises commemorating 150th anniversary of First Continental Congress—Philadelphia, Pa., Sept., 1924:*

"If the people lose control of the arteries of trade and the natural sources of mechanical power, the nationalization of all industry could soon be expected. Our forefathers were alert to resist all encroachments upon their rights. If we wish to maintain our rights, we can do no less."

"It is very difficult to reconcile the American ideal of a sovereign people capable of owning and managing their own government with an inability to own and manage their own business."

"We are too solicitous for government intervention, on the theory, first, that the people themselves are helpless, and second, that the Government has superior capacity for action. Oftentimes, both of these conclusions are wrong."

*Extract from an address by President Coolidge at the dedication of a monument to the dead of the American Expeditionary Forces at Washington:*

"You want a free and fair opportunity to conduct your own business and make your way in the world without danger of being overcome by a government monopoly. When the government goes into business it lays a tax on everybody else in that business, and uses the money that it collects from its competitors to establish a monopoly and drive them out of business. No one can compete. When the Government really starts into a line of business that door of opportunity is closed to the people. It has always been an American ideal that the door of opportunity should remain open."

*Extract from an address by Secretary of Commerce, Herbert Hoover:*

"I would like to see an independent investigation in the relative cost of construction of public work depart-

mentally as opposed to contract. I believe that there would be here demonstrated a great public waste. It is my belief, as an engineer, that construction by contract of public works makes for national economy."

*From an article in the Nation's Business for October by Admiral Leigh C. Palmer, President, Emergency Fleet Corporation, I quote the opening paragraph:*

"A highly competitive international shipping line under government operation or control and supervision is at a great disadvantage as compared with a line operated under an efficient private commercial corporation."

At a meeting of the executive board of the Associated General Contractors of America, held at the Hotel Washington, May 20, the following statements were made:

That the Corps of Engineers of the United States Army were ignoring and clearly intended to continue to ignore the plain intent of the Arlington Memorial Bridge Bill in preparing to construct that bridge with their own forces and equipment instead of by the contract method.

That they were in this case simply following a system which they have applied in constantly increasing ratio from year to year during the last quarter century, viz.: Of doing as much as possible of the construction work placed under their charge with equipment purchased for and owned by the United States, operated under the "day labor" system with man power employed by them.

That the use of this system resulted in great waste of the funds of the United States, which waste must necessarily be borne by the taxpayers.

That the results of numerous "day labor" undertakings, as recorded in their own published records, show conclusively that they are either utterly incompetent to make advance estimates of the cost of public work (which the A. G. C. of A. does not believe), or that such work under their direction and by that method shows gross extravagance in construction; vide—The record of a bridge built by them under this method at Washington, D. C., the Francis Key Bridge, which was estimated to cost \$1,000,000, and which actually cost \$2,350,000. Also the Wilson dam and substructure of the power house at Muscle Shoals, Tenn., which was estimated in 1916 to cost \$10,700,000, on which has been expended to date, \$32,500,000, is still incomplete and will require (as estimated by competent engineering authority) an expenditure of approximately \$8,000,000 additional to fully finish. This statement of expenditure made and still to be made does not take into account capital expenditure for equipment used on the work, much

\*Paper before the American Society for Municipal Improvement.  
†Vice-president of the Winston-Dear Co., contractors, of Minneapolis, and next president of the Associated General Contractors of America.

of which will have little value to the United States after this work is done. If time permitted, many additional instances could be cited.

That since 1900, when the Engineer Corps did about 12 per cent. of the total work done under their direction by the "day labor" method and 88 per cent. by contract, by 1924 those figures had changed to 75 per cent. by the "day labor" method and 25 per cent. by contract, and that further, the total equipment owned and operated by the Corps in 1900 represented a capital expenditure of less than \$5,000,000; whereas, in 1922, the amount of capital expenditure for such equipment had increased to over \$55,000,000.

The contention in brief of the Associated General Contractors of America is that the result of this system is to enormously increase the costs of these operations to the tax-payers; that it tends to eliminate competition entirely; that it violates the principles laid down by both of the great political parties, as expressed in their platforms of 1924, and as also expressed on numerous occasions by the President of the United States, both in private and in public; the frequently announced attitude of the Chamber of Commerce of the United States; the reiterated views of the Secretary of Commerce and of many other Government officials, and held by thoughtful men of all sections of this great country, to wit: That the Government should not engage in business in competition with private enterprise. These statements were and are aimed at

tent to which the Associated General Contractors of America are able to forecast, it threatens to become still more serious.

Passing from the activities of the U. S. Engineer Corps, which is given first place in this paper because it occupies nationally the most commanding position of any group directing public construction, it is unquestionably true that the use of the day labor method in this class of work has been constantly increasing throughout our states, municipalities and their boards and commissions which have to do with the direction of public work.

For several years the State of Michigan has constructed and paved most of its highways by this system. In the writer's own city of Minneapolis, all of the street paving and all of the sewer work for many years past, the two most recently constructed important bridges over the Mississippi river, and sundry other public works, have been built by the day labor method, and the city has already inaugurated the construction of a third bridge across the Mississippi river by the same method. The writer will not try your patience in the attempt to enumerate more than a small part of the operations with which he is acquainted in which this method is invoked.

The following list, which is of course in a number of cases more or less approximate owing to the impossibility of getting scrupulously accurate cost records, is fairly illustrative of the general condition.

Name of Project	Day Labor Costs in Actual Cases		% of excess cost	Probable loss to Public
	Engr's Est. or Contr's Bid	Cost by Day Labor		
Calif highway (a).....	\$117,000	\$160,000	37	\$43,000
Calif. highway (b).....	43,000	81,000	88	38,000
Gila dam, Arizona.....	800,000	2,000,000	150	1,200,000
Municipal garage, Detroit, Michigan.....	550,000	694,000	26	144,000
Michigan highways 8 miles in Genessee county.....	280,000	400,000	43	120,000
Watervliet, Michigan high school.....	150,000	210,000	40	60,000
Wyandotte, Michigan—school.....	884,000	1,145,000	30	261,000
Bay City, Michigan—schools (2).....	930,000	2,217,000	138	1,287,000
Munising, Michigan—high school.....	285,000	415,000	45	130,000
Levee construction—Third Mississippi River District—1918-1923, 12,000,000 cubic yards.....	4,038,000	5,154,000	27	1,116,000
Mississippi river bridge, Minneapolis, Minn.....	450,000	1,000,000	122	550,000
Ashland reservoir, Denver.....	104,000	120,000	15	16,000
16th Street viaduct, Denver.....	420,000	668,000	60	248,000
23 reclamation projects.....	63,000,000*	122,000,000*	94*	59,000,000*
St. Louis sewers.....	383,000	426,000	11	43,000
Francis Key Memorial Bridge, Washington, D. C.....	1,000,000	2,350,000	135	1,350,000
	73,434,000	139,040,000	88	65,606,000

a system and not at the United States Engineer Corps as individuals.

An emphatic and heated denial of all these statements has been made by General Taylor, Chief of Engineers, and Colonel Sherrill, Executive Officer of the Committee on Public Buildings and Grounds of the District of Columbia. Except that it may be difficult to prove the "intention" of the Corps regarding the method of constructing the Arlington Memorial Bridge, every statement made can be substantiated by the published records of the Corps. The situation is already a matter of serious concern to the people of the United States and to the ex-

The writer has been asked why the comparison between actual "day labor" cost and the contractor's bid is not used in all these citations. The answer is that in a majority of the instances cited, no bid from contractors was asked for or received.

The most ardent proponents of the "day labor" plan are the most persistent opponents of receiving bids on such work, because they know that one of two results would follow. Either that the cost of the project would be shown to be

\*In fairness to the Reclamation Service it should be recognized that some of the original plans on which the \$63,000,000 estimate was based were modified and the work increased, but this by no means accounts for the over-run of 94 per cent.

so great as to cause its abandonment, at least temporarily; or, that if they decided to construct with their own forces the comparison of the actual cost—if honestly and accurately disclosed—with the contractor's bid would operate to destroy the "day labor" method. Many of the supporters of this method are actuated by political rather than economical motives.

Suffice it to say, that this system is widespread and that there is probably no state in the Union in which it is not in use to a greater or less extent. The Associated General Contractors of America alleges, and in many instances proof of the truth of the allegation is available, that almost invariably the cost to the public of work done by this method is in excess of that which would have obtained if done by contract. It is not always possible to prove this for two reasons. First, that in many instances no bids from contractors are asked for or received, and second, in many cases no accurate cost record of the work is obtainable.

While this situation is a matter of concern to responsible contractors, it is of infinitely more concern to the taxpayers. The increased cost of work by this method must of necessity increase the amount of direct tax, and it has its effect indirectly in that it causes a loss to the government, state or municipality, of the tax which would have been paid by private individuals on the income from and equipment used in such work.

It has been charged that the attempt of the Associated General Contractors of America to give the fullest possible information to the public regarding the effect on taxation of the constantly increasing volume of public construction performed by the "day labor" method, is inspired by "selfish interests."

To the extent that members of this Association hope to benefit by a return to what it regards as the reasonable and proper method of constructing needed public works, we concede the truth of this charge. We are assured, however, that the benefit to be derived from such action will accrue in much larger measure to the general taxpayer. Any and every individual in the United States who is not a dependent on an individual or family, or is not a charge of or upon the state, is either directly or indirectly a taxpayer.

There are at least four important reasons why the "day labor" method is generally unsound, as follows:

1. It is contrary to the generally accepted view that the Government should not engage in business in competition with private enterprises when and where private enterprise and initiative is available.

2. It is socialistic in tendency.

3. It makes possible the organization of a machine, which will assure the continuing political control of all activities of that department of government, by the agency of that government using this method.

4. It fails to recognize a well established principle which demands the employment of profes-

sional skill when and as such skill is of value. We do not employ an engineer to treat us in case of illness, an architect to conduct our cases in court or elsewhere when legal knowledge is requisite, a doctor to locate our railroads, nor a lawyer to design our buildings.

The A. G. C. of A. affirms that the business of construction has become a profession, and that the professional skill of available contractors is such that they can in general assume charge of public construction under the supervision of the engineer or architect, and so carry on the work as to save money for the taxpayer; meantime securing a greater or less compensatory profit for themselves.

It is further claimed that in the event that the contractor, through incompetence, or for any other reason, does not receive a sufficient price for his work to secure him against loss, he bears that loss, whether individually or through his bond, and that it does not fall upon the general taxpayer. Where the cost of work on the "day labor" plan exceeds the advance estimate, or the appropriation, or both, such excess is, of course, passed along to the general taxpayer.

The New York Commercial has been so impressed with the threat of this epidemic as to publish a series of twelve *front page* articles upon the subject. These articles began in the issue of September 22, and ended with that of October 5. Subsequent issues have additional matter of value on this point. Those of you who are interested can obtain reprints of the articles by application to the New York Commercial.

If the contractor has nothing of value to offer the community in the conduct of his business it is certainly time for him to find it out and either to retire from active business as an obsolescent and useless burden on the public or to learn some new occupation in which he can be of service and incidentally avoid becoming a charge upon the state.

Is it possible that the skill developed by years of intensive training, which an overwhelming majority of the responsible contractors now operating have undergone, has no value in producing, through intelligent supervision by trained men of individual initiative, better methods, better workmanship and better progress in all lines of construction? If this is possible, much of the work of our public schools, universities and colleges—especially that of our technical schools—is wasted.

It seems quite reasonable to expect that the first question that will be asked by anyone interested in this subject will be—"Assuming that the conditions exist as stated, what is the remedy?"

The writer suggests as a preliminary step the general acceptance and adoption of the following declaration of the "Taxpayers Association of Hennepin County," Minnesota, as quoted from *The Taxpayer* of September, 1925:

**SUGGESTED COURSE TO BE FOLLOWED BEFORE ACTUALLY ENGAGING IN WORK OF PUBLIC CONSTRUCTION**

In order to assure, and as far as possible, guarantee, to the taxpayer that all municipal work of public character will be done at the least possible cost compatible

with good workmanship and efficiency, The Taxpayer suggests that in conformity with the spirit of Chapter 274, Laws of 1921, the following steps or proceedings be taken before any public work can be actually started.

1. The due authorization of the work to be performed, by legislative or other appropriate action, on the part of the body or agency clothed with the power and charged with the responsibility to order and direct the doing of public work, and having the means of providing for the payment thereof.

2. The preparation by competent engineers or architects, or both, of plans and specifications, with accurate quantity surveys and an approximate estimate of cost; and, with competent legal cooperation, of a suitable form of contract.

3. If and when the necessary appropriation has been made by the proper appropriating body, and the funds are in the hands of the authorized disbursing agency, or will be available when required, advertisements for bids should be published, in manner provided by law, in proper form, setting forth:

(a) The qualifying requirements for bidders.

(b) The time when, the place where and the conditions under which, copies of the plans, specifications, quantity surveys, form of contract, and other information may be obtained.

(c) The time when, and the place where, bids will be received, publicly opened and read.

4. The prompt award of a contract to the lowest responsible bidder, who should be required to furnish a satisfactory and sufficient bond for the performance and completion of the work within the time and for the gross amount, or at the unit prices, named in his proposal—except and unless the agency directing such public work may for sufficient cause elect:

(a) To reject all bids and advertise the work for other proposals; or

(b) If, for good reasons given, it be considered that the work cannot be let by contract for a price as low as it can be done by the agency in question, to reject all bids and proceed under the method known as "the day labor system."

5. In the event that alternative "(b)" in Section "4" above is adopted, an accurate record should be kept, showing, properly classified, all expenditures of every kind and nature incurred in the prosecution and completion of the work, including the cost of all material and supplies, engineering, architectural and other services, overhead, rental and depreciation of equipment employed, insurance and any and all other items of cost and expense entering into the work.

6. A summary of such expenditures should be published in the official newspaper of the city within 60 days after the completion of the work; and a transcript of the itemized detail should be promptly procurable from the recording officer by an interested taxpayer requesting the same, upon the payment of a reasonable charge for copying.

The American Society for Municipal Improvements must of necessity be interested in taxation—must earnestly desire to know that the taxpayer's money is being expended in such manner as to produce commensurate value.

The examples of waste due to this cause that are listed in this paper are only a few of those recorded by our Association; but they are sufficient to show conclusively that this waste exists and that it is widespread in operation and effect.

A custom which requires demagogism, subterfuge and, on the part of some of its proponents, absolute falsehood in its defense cannot long endure when the facts are public property.

It is the purpose of our Association to give these facts to the interested public as rapidly

as they can be collected and verified. We expect this to result in a demand in no uncertain tone for the abandonment of this practice whenever and wherever it can be demonstrated to be uneconomical—and that this demand will be voiced by that most directly affected group—the taxpayers.

## Incinerator Design and Construction

**Principles suggested as basis for specifications for refuse incinerators, suggested by committee of American Public Health Association.**

The Committee on Refuse Collection and Disposal of the American Public Health Association, Sanitary Section (in future to be known as the Public Health Engineering Section), C. A. Holmquist, chairman, John H. Gregory, M. N. Baker, Edward D. Rich and Samuel A. Greeley at the St. Louis convention included in its report twelve principles suggested as the basis for preparing specifications for refuse incinerators and conducting acceptance tests thereof. These were based largely on the symposium prepared by the committee last year. These principles are as follows:

1. For reasons of sanitation it is believed advisable to keep garbage and refuse in separate containers at the house. The collection, however, may be either separate or combined depending on local conditions.

2. Household and industrial ashes should not be incinerated but should be hauled directly to the dump or fill.

3. The revenue derived from salvage and utilization of municipal refuse will probably never equal the total cost of collection and disposal. The possibility of the utilization within the works of power generated by incineration of refuse is worthy of consideration.

4. In selecting a site for the location of the incinerator due consideration should be given to its accessibility for collection districts, the character of neighborhood as regards use and occupation, and its elevation with reference to the surrounding territory in order to minimize the possibility of nuisance.

5. Before specifications are drawn up certain fundamental data regarding the refuse should be obtained, such as total tonnage, relative proportion of the various constituents by weight and volume, calorific value, etc.

6. Specifications for the work should always be drawn up and should include the following points: (a) The plant should be planned for at least two units for flexibility and reliability of service and to facilitate making repairs. (b) Good engineering standards for materials of con-

struction and quality of work should prevail. (c) The quality of fire brick used in the furnace should vary according to the demands in the different parts of the furnace, as to porosity, refractoriness, coefficient of expansion, hardness and ability to withstand abrasion. (d) The lining and arches of the furnaces should be so constructed as to prevent warping and cracking of the exterior walls. (e) The grates should be so designed as to make ample provision for expansion and contraction, to facilitate clinkering and to prevent overheating. (f) Suitable drying grates or hearths should be provided where garbage and other refuse having high moisture content are to be incinerated. (g) A combustion chamber of suitable size and arrangement to facilitate combustion and arrest dust should be provided. (h) If a boiler is installed to utilize the heat produced at the incinerator, due consideration should be given to the character and calorific value of the refuse in order that the boiler may be so located as to prevent undue cooling of the gases before combustion is complete. (i) Sufficient air, properly distributed to give complete combustion, should be provided. Forced draft with air preheated to not less than 300 deg. F. is desirable, especially in the larger plants. (j) Simplicity and ruggedness in design should be sought in all mechanical devices. (k) Proper means of charging the furnace, with special provision for preventing undue loss of heat and the escape of gases of combustion during charging, should be provided. (l) Where the type of furnace or the local conditions require temporary storage of refuse, the storage bins or containers should be so constructed as to facilitate ready cleansing and a minimum handling of the refuse. (m) Provision for rapid clinkering and for the disposal of clinkers and ashes should be made. (n) Suitable instruments for measuring and recording essential data and results of operation of various parts of the plant are desirable. The minimum equipment for larger plants should be a continuous recording radiation pyrometer, a CO<sub>2</sub> recorder, thermometers or pyrometers for recording the temperatures of chimney gases, preheated air and outside air, and draft gages for recording pressures in ashpits, flues and chimney. (o) Suitable scales should be provided for weighing the refuse delivered to the plant. (p) Ventilation of the plant should be provided in such a way as to prevent outside nuisance from odors or dust. (q) In general the plant should be so designed as to enable ready cleansing of floors and apparatus, and the necessary facilities should be provided for that purpose.

7. Each bidder should submit with his bid a list of two or more municipal plants operating successfully in the United States under conditions similar to those obtaining for the proposed plant and of the same pattern as the incinerator on which his bid is based.

8. Contract forms should be prepared and bids should be submitted in such a manner as to afford ready comparison of bids on unit prices

of construction, and efficiency of operation, including annual charges of operation, interest and depreciation, under the stated guarantee.

9. The contractor should make certain guarantees of efficient and economical operation under bond covering the following points, and the final acceptance of the plant should be contingent on the results of a test run of not less than 10 days duration, conducted under certain specified conditions: (a) Personnel required to operate the plant for a given tonnage of refuse of a stated approximate percentage of constituent materials. (b) Net cost per ton for incinerating refuse containing certain percentages of water and combustible. Where additional fuel is needed for complete combustion, the maximum quantity of fuel required per ton of refuse (usually 200 lb. of coal or the equivalent of oil or gas per ton of garbage is necessary for complete combustion). (c) Number of pounds of refuse (of specified composition) to be incinerated per square foot of grate area, per hour. (d) Probable gross rate of evaporation in boilers from and at 212 deg. F. per pound of refuse (of specified composition) consumed. (e) Minimum combustion chamber temperature 1,250 deg. F. Average combustion chamber temperature 1,400 deg. F. (f) No smoke to be emitted from the stack of a degree of darkness or density greater than that shown by Chart. No. 1 of Ringelmann's smoke scale. (g) No dust or noxious odors to be emitted from stack or plant. (h) All refuse, except metals and incombustible materials, to be evaporated and burned to a mineral ash practically free from organic matter. (i) The city to be secured against litigation which may be brought for use of any device or patented article included in equipment.

10. The method of conducting the final tests and the personnel of the committee of judges should be specified. (It is desirable that the contractor carry out a preliminary test for at least a 5-day period.)

11. The procedure to be followed in cases of failure of the plant to meet the requirements, should be specified. (Frequently the contractor is granted a 60-day period in which to make changes preliminary to a second and final test.)

12. During the preliminary operation and test periods all operations should be carried on by and under the control of the contractor, who should supply the supervision and all labor and fuel necessary for the operation of the plant. The municipality should deliver at the plant the refuse to be incinerated.

### Measuring Roughness of Roads

A new device known as a "roughometer" has been perfected by the U. S. Bureau of Public Roads. It is attached to an automobile and determines the relative roughness of different sections of the road surface. The principle upon which it is based is different from that of any other instrument now in use for this purpose.

# The A. S. M. I. Convention

**Papers and discussions thereon, officers elected and constitutional amendments approved. Paving, city planning, street lighting, sewerage, and refuse collection the topics which received the most attention.**

The 31st convention of the A. S. M. I., held in Des Moines on October 26th to 29th, was generally voted a very successful one. There were registered about 100 active members and 35 associate members, while the guests totaled 150, about 70 of whom were from Des Moines. Many of the members came from a considerable distance, Boston, Ottawa, Can., Portland, Ore., and Lakeland, Florida, being among the more distant places represented.

Two changes in the constitution were voted by the convention to letter ballot on recommendation of the executive committee, these being a change in the selection of secretary from election by the members at large to appointment by the executive committee; and change in the provisions relative to specification committees so that a minority of the positions in any committee may, at the discretion of the president, be filled by associate members, the number of members being limited to 7.

It has been evident for some time that the society had reached a point in size and importance where the duties of the secretary were greater than could be performed by a practicing engineer in time which he was able to spare from his business, and that some other arrangement was imperative. Anticipating favorable action on the proposed amendment, the executive committee selected C. W. S. Sammelman, secretary of the Engineers Club of St. Louis, as secretary of the society, an arrangement having been made whereby he could hold both positions; which arrangement was explained to the nominating committee appointed later on during the convention, and Mr. Sammelman was duly nominated and elected to the position of secretary. It is believed that two important benefits that will be obtained by having a full time secretary will be the getting out of the "Proceedings" of the society much more promptly, and a membership campaign whereby the society will increase considerably in size instead of making practically no growth, as has been the case during the past few years.

The other officers nominated and elected for the year 1925-6 were as follows: for president, T. Chalkley Hatton, of Milwaukee, Wis.; for first vice president, C. A. Poole, of Rochester, N. Y.; for 2nd vice president, John B. Hittell, of Chicago, Ill.; for 3rd vice president, John Klorer, of New Orleans, La.; for treasurer, P. L. Brockway, of Wichita, Kan.; and members of the finance committee, George F. Fisk of Buffalo, N. Y., W. B. Fowler of Memphis, Tenn., and K. C. Kastberg, of Des Moines, Ia.

The holding of the Asphalt Paving Conference at Detroit on the week before this convention had been found to interfere with attendance at both, since a number of public officials had not found it practicable to attend conventions for two weeks in succession. It was accordingly suggested by some that these two meetings next year be held at the same place and on consecutive days, as for instance, the A. S. M. I. from Monday to Thursday and the asphalt conference from Thursday to Saturday, with possibly a joint session on Thursday. The selection of place and time of meeting for next year was placed in the hands of three members of the executive committee, the choice to lie between Dallas, Tex., and Columbus, Ohio and Memphis, Tenn., unless there should be some unforeseen conditions that would seem to make another choice desirable.

The executive committee met at noon on Monday; and, beginning at 2 P. M., the afternoon was devoted to meetings of several committees on specifications.

The convention was formally opened on Monday evening with an address by the Mayor, Carl M. Garver, and a response by vice president Hatton, followed by the annual address by President Dalton. The session closed with the selection of committees on nominations and resolutions, and the introduction of the proposed amendments to the constitution already referred to.

## TUESDAY'S SESSION

On Tuesday morning, a paper entitled, "Developments in the Theory and Practice of the Design and Construction of Bituminous Pavements" was presented by Hugh W. Skidmore, and Prevost Hubbard described a "Test for Stability of Sheet Asphalt Pavement Mixture" which has been developed this year by the Asphalt Association and described briefly in PUBLIC WORKS. The "Behavior of Concrete Pavements under Service Conditions" was discussed by H. Eltinge Breed, following which P. L. Brockway, in a paper entitled "Abrasion Test for Concrete," described a method devised for making a rattler test of concrete molded in balls instead of bricks or blocks, because the great loss due to breaking of the edges was thought to be unduly severe on that material. Mr. Brockway made 6-inch spheres in cast iron molds. These were weighed, left in the rattler for a given number of revolutions, then weighed again and the loss noted, as a percentage of the weight of the ball at the beginning of the run. It was found that, in general, the loss for any particular ball remained at a uniform per-

tage as the ball wore smaller and smaller in successive runs. It was also found that, used as a test of the relative desirability of several aggregates, the results checked with actual experiences with the use of such aggregates in concrete roads. T. H. Johnson, of Sioux City, Ia., questioned whether the effect of tamping and otherwise working the surface of a concrete road did not so change its character that the ball test would be of little value in connection with road work.

R. H. Simpson presented some figures on the relative cost of maintaining asphalt and brick pavements which were recognized by the convention as being of great value and unusually informative. This paper was discussed by G. W. Tillson and others. Prof. A. H. Blanchard then read a paper entitled, "Three-Lane Two-Way Roadways" in which he claimed that in such a road the third lane was used chiefly by reckless drivers and that it was therefore a cause of accidents and was not only of no value in facilitating traffic, but was a danger which should be eliminated. This paper was discussed by C. C. Brown, George W. Craig, and others.

The rest of this session was devoted to papers by associate members. Moving pictures showing "Finishing Machines on Construction of Concrete City Streets," with running comments by Lion Gardiner, vice president of the Lakewood Engineering Co., showed the various methods adopted for utilizing highway finishing machines in the construction of city roadways. The next paper was one by A. S. Mirick entitled "The Salvage Value of Brick Pavements," in which were described various methods of using brick from old pavements in addition to that of turning them and relaying them in the pavement. "The Use of Brick Less than Three Inches in Depth" was discussed by Col. W. L. Benham, in which he advanced the opinion that since only a fraction of an inch of brick was worn off by modern rubber-tired traffic, and a concrete foundation gave better and more uniform support than the kinds formerly used, a brick 2½ inches deep would give satisfactory service and economize in cost. The session closed with a paper by Ralph L. Warren, read by George Warren, entitled "The Irresponsible Bidder," in which such bidder was charged with responsibility for poor work, below-cost prices, and many other results objectionable alike to the contractors, the engineers and the municipalities.

#### WEDNESDAY'S SESSIONS

The morning session opened promptly at 9:30 with the report of E. A. Fisher as chairman of the committee on city planning. Following this a paper by James B. Weaver entitled, "The City Plan and the Community Consciousness" was read by title, having been published in advance papers. The city plan of Des Moines was then explained by C. A. Taubert and that of St. Louis by Harland Bartholomew, following which there was discussion of certain features of the papers, including excess condemnation in Michigan, elimination of grade crossings, etc. In

connection with the latter, it was explained that in eliminating crossings of roads leading into Detroit, a gentleman's agreement had been entered into between the railroads and the county whereby each road is to contribute \$150,000 a year and the county to double the amount so raised, giving about two million dollars a year for grade crossing elimination. Also it was stated that in New York State, the city pays 25 per cent., the state 25 per cent. and the railroad 50 per cent. (On November 3rd an amendment was adopted by popular vote whereby the state can advance to the railroads their share of the cost of this work, so as to expedite the completion of grade crossing elimination throughout the state.) Mr. Horner explained many of the features which made the city plan valuable to city engineering departments as a basis for planning sewers and other improvements. In response to a question as to the cost of carrying out some of these city planning improvements, Mr. Bartholomew stated that the comprehensive bond issue voted last year by St. Louis covered 10 years of development and will cost the taxpayers only 69 cents a year for each \$1,000 assessed valuation.

George L. Warren then read a paper postponed from the previous afternoon, entitled, "Municipal Finance and Street Improvements," an abstract of which will appear in PUBLIC WORKS. This paper brought out considerable discussion in which C. C. Brown, W. W. Horner, Geo. W. Tillson and others took part. In brief, Mr. Warren recommended assessing the cost of pavements, resurfacing and renewals against abutting property, permitting the payment in cash or in ten annual installments, but the contractor to be paid immediately by the city, for which purpose it would issue temporary notes or bonds, general obligation bonds being issued for carrying the cost until the end of the 10-year period. Mr. Tillson stated that New York has something similar to this in the form of a street improvement fund which is practically a revolving fund started by the issuing of bonds and increased from time to time, as may be necessary, by the issue of more bonds. Practices in other cities were discussed by Messrs. DeBerard, Simpson, Craig, and McVeah.

On Wednesday afternoon the members and guests were driven around the city in automobiles furnished through the courtesy of the local public utility companies and the Mack Motor Truck Co.; this including a visit to the new power house of the Des Moines Electric Company and to the waterworks pumping station.

On Wednesday evening, Ralf Toenseldt presented a report of the Committee on Street Lighting which was followed by a paper by L. A. S. Wood of the Westinghouse Electric and Manufacturing Co. entitled, "Cost of Inadequate Street Lighting;" figures being given on which to base an estimate of the loss of life and property, crime, etc., due to poorly lighted streets. This was discussed by Mr. Klorer. F. H. Winkley of the General Electric Co. illustrated "Mod-

ern Street Lighting" by lantern slides showing standards and lighting units used in a number of cities. T. W. Rolph of the Holophane Co. then described what is meant by, and the advantages of, asymmetric street lighting.

Considerable discussion concerning day labor construction in public works followed the reading of a paper on the subject by J. H. Ellison, a contractor of Minneapolis and official nominee for president of the Associated General Contractors, which paper is published elsewhere in this issue. Mr. Horner explained the cost of St. Louis day labor referred to in the paper, but both he and Mr. McVeah and most of the other speakers agreed in general with Mr. Ellison's conclusions, most of them making reservation that there might be conditions when day labor by municipal or other governments became necessary, as when the contractors appeared to combine for putting over excessive bids.

The Des Moines waterworks was then described by Charles S. Denman with lantern slides showing the ornamental lagoons and lakes at the pumping station. The report of J. B. Hawley, chairman of the committee on waterworks, who was absent, was presented in abstract by Secretary Brown and discussed by Edward Bartow, A. F. Macallum and others.

#### THURSDAY'S SESSIONS

Thursday morning was devoted to the subject of sanitation and opened with a report by Samuel A. Greeley, chairman of the Committee on Sewerage, Sanitation and Garbage Disposal, in which he described recent development in the use of sewage sludge. A paper by A. L. Kurts entitled "Value of Comprehensive Plans for Sewer Systems" was read by one of the members in his absence. Another paper on the same subject was presented by Mr. Greeley. City engineer Katsberg then described, with the aid of maps, the sewerage and drainage projects of Des Moines. The method of conducting tunnel work in large sewers in sand and water bearing gravel in St. Paul was described by George M. Shepard, with photographs of work in that city, most of which was done by the poling board method. S. Cameron Corson having asked the opinion of engineers present whether it would be better to carry a sewer 20 or 30 feet below the surface in sandstone in tunnel or open cut, Mr. Hatton stated that in Milwaukee sewer construction, the contractors can choose either tunnel or open cut and invariably have chosen tunnel where a sewer was 20 or more feet deep and some times where only 14 feet. The question also having been raised whether it was just for a state board of health or other authority to require a city to carry to its boundary, sewers large enough to carry the flow of territory beyond the boundary which had no other outlet, Mr. Kingsley and Mr. Horner expressed the opinion that it was advisable as a matter of policy for the city to do so, since territory beyond the boundary sufficiently developed to re-

quire sewers, probably would be annexed to the city at some time and that to provide outlet across the city for such district would then cost many times the increased capacity necessary to carry this sewage in the sewer being built at present.

A paper on "Stream Pollution" by Hans Pedersen and one by J. K. Hoskins entitled "Relation between Stream Pollution and the Extent of Sewage Treatment Required" were then read by members in the absence of the authors. This was followed by a series of moving pictures of the Milwaukee sewage treatment plant shown by Mr. Hatton, which gave an excellent idea of the construction and operation of this, the largest activated sludge plant in the world. Two papers on "Preliminary Treatment of Sewage as Affecting Rates on Sprinkling Filters" were presented by A. L. Fales and F. W. Mohlman and were read by members in the absence of the authors.

In the afternoon, two papers on experiences with separate sludge digestion were presented by L. R. Howson and C. E. Keefer. Mr. Howson stated that in the Madison, Wis., plant using separate sludge digestion, there were no odors and no clogging of the nozzles or of the filter beds. This plant is provided with primary, secondary, and colloidal tanks. At Lincoln, Neb., there are six settling tanks, sludge tanks having a capacity of one cubic foot per capita. The sewage tends to form scum rather than a sludge. Other plants at Great Lakes, Ill., and Hartford, Wis., were described. Mr. Keefer stated that in the Baltimore plant using separate sludge digestion there has been no foaming and there is little odor if the crust of the scum is kept intact.

Three papers on the subject "Equipment for the Collection of Garbage and Other Refuse Materials" had been prepared by Paul Patton, W. J. Galligan and R. E. Stoelting, none of whom was present, but the papers were read by the secretary and others. In discussing this, Mr. Macallum stated that in his experience,  $2\frac{1}{4}$  miles was the limit of economical haul of refuse with horses. T. J. Lucas then presented a paper entitled "Power Plant Development" which had been postponed from Wednesday evening.

In presenting a report as chairman of the Committee on Specifications for Bituminous Pavements, E. A. Kingsley recommended that next year's committee prepare specifications for rock asphalt and stone-filled sheet asphalt. George F. Fiske, chairman of the Committee on Specifications for Brick Paving, had no new specifications to offer but reported the elimination of one more size of brick from the standards as recommended by the Washington conference. The concrete pavement specifications which had already been published were ordered to letter ballot, which action was also taken with respect to the stone block specifications. E. R. Dutton, Chairman of the Committee on Specifications for Wood Block Paving, reported that this type of pavement seemed to be going out of use, partly because, as blocks became old,

they were more subject to swelling and decay. Of forty cities questioned on the subject, about half stated that they covered their old wood block pavements with tar, about 25 per cent. used oil, and the remaining 25 per cent. had given no treatment of this kind to its pavements. Frank R. Allen, chairman of the Committee on Sewer Specifications, reported that they had no changes to recommend although some had been asked for by the reinforced concrete pipe interests, especially with reference to the rejection of pipe for a first crack. This subject will be studied by the committee and reported upon at the next convention. The A. S. T. M. committee C4 is considering several points in sewer specifications which also will be ready for reporting upon by next year. The committee on Specifications for Street Railway Paving and Track Construction had prepared some changes in the specifications which, after some discussion by the convention, were referred back to the committee with a view to having them considered by a joint committee of this society and the American Street Railway Association. W. W. Horner, chairman of the Committee on Municipal Contract Forms, presented a form which was based upon the standard form prepared by the Associated General Contractors and others, and which was generally approved by Ward P. Christie and J. H. Ellison, of the A. G. C., except that they urged including a provision for arbitration.

This ended the program for the afternoon session, but as little remained for the evening session, it was decided to endeavor to complete the work of the convention before adjourning. J. C. Grinnalds, chairman of the Committee on Public Welfare, presented a report, suggesting that the committee carry out, in its successive annual reports, a program on public welfare, many features of which are included under the heads of health, safety and morals, with convenience, art, aesthetics, etc., as secondary considerations. A paper on "Municipal Finance" by Chester E. Rightor had been published in the advance papers and was read by title. Reports were then heard from the representatives of this society in other organizations.

The session and convention concluded with the report of the secretary, treasurer and finance committee. The secretary's report showed \$6,443 received during the year while the disbursements amounted to \$7,033. However, these disbursements included several bills held over from the previous year while this year all bills had been paid to date, and the society holds a \$1,000 liberty bond. About 75 members had been added to the society during the year but practically the same number had been lost through resignations and those dropped for non-payment of dues.

Adjacent to the convention hall, and so located that all attending the convention meetings must pass through it, was a tastefully arranged exhibit room in which booths were occupied by the following exhibitors: Stoner McCray Sys-

tem, Flint Brick & Coal Co., Standard Oil Co. of Indiana, Ford Motor Co., Midwest Paving Brick Mfrs. Ass'n., National Paving Brick Mfrs. Ass'n., Asphalt Ass'n., W. & L. E. Gurley, Hawk-eye Portland Cement Co., National Steel Fabric Co., Iowa Valve Co., Pittsburgh-Des Moines Steel Co., Blaw-Knox Co., Public Works Journal, Lakewood Engineering Co.; Marsh Engineering Co., Des Moines Steel Co., American Vibrolithic Corp., Serviced Products Corp., The American City Magazine, Atlas Lumnite Cement Co., Portland Cement Ass'n., National Meter Co., Warren Bros. Co., G. K. Sales Agency, U. S. Bureau of Public Roads, Lock Joint Pipe Co., What-Cheer Clay Products Co., Eureka Fire Hose Mfg. Co., Tnemec Paint & Oil Co., Pierce Robinson Landscape Architect, Des Moines Electric Co., Des Moines Gas Co., American Hume Concrete Pipe Co., Clay Products Ass'n., Chicago Concrete Post Co., Crouse-Hines, Prestite Engineering Co., General Electric Co., Granite Paving Block Ass'n., Kentucky Rock Asphalt Co., Giant Manufacturing Co., Westinghouse Electric Co., Pyramid Portland Cement Co., and Southern Surety Co.

### Emulsified Asphalt for Bridge Floors

Owing to the remoteness of many highway bridges in California, and the difficulty and expense of bringing to them a plant and roller for laying hot asphalt, the California Highway Commission this year decided as an experiment to surface seven timber-deck bridges with cold asphalt. The bridges so surfaced are supported by concrete piles and bents carrying a heavy wooden deck. The material used was that known as "laykold," which was shipped in barrels of approximately 400 pounds and mixed with local sand and rock.

In making the mixture, a man with a large paddle first mixed the "laykold" in the barrels, which was then dumped into large mixing boxes and worked with a hoe until thoroughly broken up. This material was then placed in a one-bag Jaeger mixer, and to it was added aggregate and sufficient water to give the right consistency. The batch was mixed for 1½ to 2 minutes and then dumped into a box, shovelled into a truck and hauled to the bridge.

The bridge floor was first swept clean and a coat of two parts water to one of laykold was broomed over the surface. The mixed surfacing material was then dumped on to the bridge and spread and tamped in the same way as concrete, using a wooden tamper 22 feet long cut to the crown of the bridge. After from two to four hours it was rolled with a 750-pound hand roller. When thoroughly dry, a seal coat of one part water and one part laykold was spread over the surface and covered with a coat of coarse screenings, after which it was again rolled. The labor employed was one mixer operator, two laborers mixing laykold, three men to wheel and shovel aggregate, two spreaders and two tampers.

# Service Record and Maintenance Costs of Asphalt Pavements\*

**Actual costs of maintaining asphalt pavements in Columbus, O., during the past thirty-six years, grouped according to the age of the pavement and intensity of traffic, and discussion of same.**

By R. H. Simpson†

Test road experiments conducted by various agencies have resulted in information of value on construction details, and have developed for certain types the proper thickness and cross section of bases to resist the strains set up by moving loads. But such tests do not tell the whole story of pavement wear or weakness, because they do not properly represent traffic conditions, nor take into consideration all of the factors that enter into the wear or destruction of pavements. The continuing action of the elements is lacking, and while the wear of a pavement is influenced largely by the traffic it receives, it is the action of traffic combined with such destruction agencies as rain, snow, ice, frost, etc., that bring out the defects in pavements or cause failure in them rather than by traffic alone.

Notwithstanding the fact that there is a feeling among some that rubber tired traffic does not appreciably abrade hard-surface pavements, many engineers do not share this view. A careful observation of pavements that are subjected to such traffic as exists on many streets of any American city will convince anyone that our hard-surface pavements of all types are showing evidence of wear, and we all know that expenditures for the maintenance of all pavements is assuming larger proportions year after year. It follows, therefore, that up-keep and renewals are important factors to be considered in any proposed construction, and a knowledge of repair costs and probable life is essential in determining the economical pavement. It is the ultimate cost and not the first cost that, from the economical standpoint, should indicate the type of pavement to be adopted. The road problem in the past has been one of construction. In the future it will be largely one of maintenance and renewal. During the past decade there has been a feverish desire to build as many miles of road as possible with the funds available. Now the annual expenditures for maintenance is approaching in amount that for construction, and in another decade we will undoubtedly see a much greater portion of highway funds expended for up-keep and renewal than for construction.

Of all of the literature on the subject of pavements, it is remarkable that so little has been published on repair costs or wear. Engineering literature is rather voluminous on construction, but we search in vain for definite data on the cost

of maintenance and up-keep. It is, of course, true that many of the highway departments of the various states have published reports on road maintenance in terms of cost per mile, but these figures usually include miscellaneous items other than actual pavement repairs, and it is therefore impossible to make any comparison between various materials or types. We have also reports on repair costs from many cities, but these figures are usually given in such a way as to be misleading because they do not take into consideration the volume and character of traffic carried or the age of the pavements. As a pavement becomes older it will cost more to maintain it, and I think we will all agree that pavements subjected to excessive traffic are the ones requiring the most maintenance, so that unless we know the age of a pavement, how it was constructed and something of the traffic it carries, the repair cost does not mean much.

In this paper there will be given some definite data on the cost of maintaining asphalt pavements. It will be given in terms of the age of the pavements, and the analysis will show costs compared for various traffic conditions. It is well to keep in mind that the figures given and conclusions drawn are based on a study of about three hundred improvements, totaling 1,800,000 square yards of sheet asphalt pavements laid in Columbus, Ohio. It is thought, however, that they will represent the average repair cost for this type of pavement in any locality where traffic conditions and construction methods and details are similar.

Before presenting these figures it will be desirable to give some information about the construction of the pavements. Prior to 1900, the asphalt pavements under consideration were laid on a six-inch natural cement concrete base. Subsequent to 1900 a Portland cement concrete base six inches in thickness has been used. The earlier mixture consisted of one part Portland cement, 4 parts sand, and 8 parts crushed stone or crushed gravel. This mixture has been strengthened from time to time, and for the past twelve years the proportions have been one part cement, 2½ parts sand and 5 parts stone. The thickness of foundation has remained at 6 inches. The asphalt mixture has followed standard practice in sand grading and has contained from ten to eleven per cent bitumen. On most of the improvements the wearing surface has been 1½ inches of sheet asphalt laid on one and one-half

\*Paper presented at the Fourth Asphalt Paving Conference held at Detroit, October 21 to 23, somewhat condensed.

† Chief engineer, Department of Public Service, Columbus, O.

inches of binder; but during the past ten years a two-inch topping has been used on heavy traffic streets. About 195,000 square yards has been laid as a resurface over old and badly worn pavements.

There are four types of old pavements that have been resurfaced in Columbus, namely, brick, boulders, stone block and macadam. About 72% of the work has been on brick, about 20% on boulders and 8% on macadam and stone block. In general it may be said that the results from stone block and brick have been uniformly successful and that in the case of the boulder pavements the results have been generally successful. The resurfacing over macadam has been of recent date, the oldest pavement having been laid in 1922.

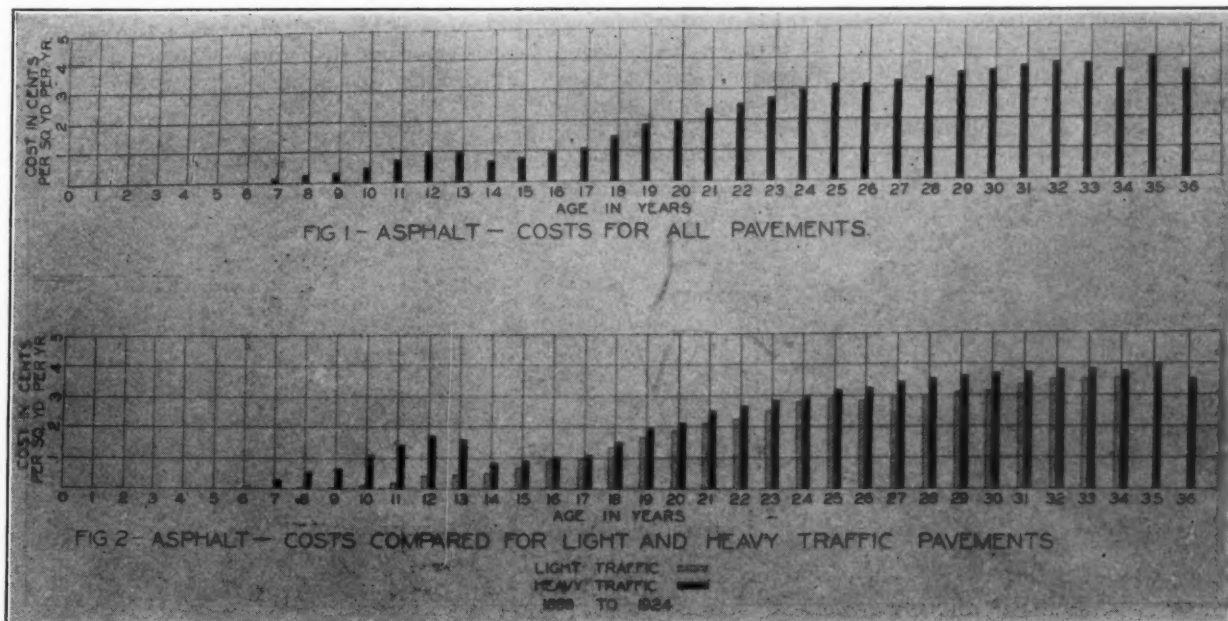
Practically all of the repair work has been done by the "cut out" method. Surface heaters have rarely been used. Prior to 1907 the repairs were made by contract, the repaired area being measured and payments made on a unit price basis. Subsequent to 1907 all repairs have been made by city forces. To ascertain the repair cost, the repaired area is measured and recorded at the time the repair is made, but the unit cost to be applied is determined at the end of the season's work, by dividing the total expense for the year, including labor, material, supplies, repairs to equipment and plant, a charge for use of plant, superintendence, etc., by the total yardage of repair made. This gives a unit cost to apply to each pavement, and a total for same that is not influenced by the location of the pavement nor its distance from the plant. A more rational comparison between pavements is thus obtained than if the actual cost of each particular improvement is used.

The maintenance of all pavements in Columbus has always been under the direction of the chief engineer of the Service Department, the asphalt maintenance being in direct charge of a

deputy engineer. A record of asphalt maintenance has been kept for many years, the data being available for all improvements constructed since the year 1888.

At the end of the year the repair costs of all pavements are recorded on cards prepared for the purpose, one side showing the construction data, and the reverse side the maintenance. The maintenance data consist of the area of the improvement; the area repaired each year; repair cost each year; the unit cost in terms of total area; the cost per yard per year; and the total cost to date or accumulated cost. The cost per yard per year is really the service test of a pavement, and gives a more rational comparison between two or more pavements than if the actual cost of each age period is used, as the latter is usually erratic because of the influence of shortage of repair funds in some years. The cost per yard per year is the average yearly cost of repairs for the period under consideration. It is obtained by dividing the total cost of repairs for the given number of years by the area of the improvement and this quotient by the years. For example, the total yardage of all asphalt pavements that have been in service 10 years, is 660,027, and the total expenditures for repairs on these pavements during this ten year period has been \$33,044. By dividing this sum by the yardage and then by ten we get \$0.005, which is the cost per yard per year for ten year old pavements. In this manner the maintenance costs have been ascertained for all asphalt pavements.

Figure 1 shows graphically the repair costs of all asphalt pavements in the city for all ages from one to thirty-six years. This is made up from the costs of about three hundred improvements, and is therefore the average cost, without any consideration being given to volume or weight of traffic. It will be noted that, except for a more rapid increase in cost from the tenth



FIGS. 1 AND 2—COST OF ASPHALT PAVEMENTS, TOTAL AND FOR LIGHT AND HEAVY-TRAFFIC PAVEMENTS.

to the thirteenth year, the cost increases somewhat uniformly each year. The increase is, however, more rapid from the fifteenth to the twenty-fifth year than for any other ten year period.

In figure 2 there is shown a comparison of the cost of repairs of light-traffic and heavy-traffic pavements. In the absence of data obtained by a traffic count, such a division is somewhat arbitrary, but in explanation it may be said that in dividing pavements into these classes, all those in business sections, in railway terminal districts, and all thoroughfares have been considered as heavy traffic pavements, and all others as light traffic. It will be noted that the repair costs for the light-traffic pavements increase rather uniformly up to the seventeenth year, after which the increase is somewhat rapid. The heavy-traffic pavements, however, show a marked increase in the ninth to the twelfth year; from the fourteenth to the eighteenth year the cost is less than at the twelfth year period, but increases again rather uniformly up to the thirtieth year. It is interesting to note that there is very little difference in repair costs of light and heavy traffic pavements after the fifteenth year. As would naturally be expected, however, the latter is in excess of the former at all ages.

A study of the repair cost data has disclosed the fact that at certain age periods there was considerable difference in cost for pavements laid prior to 1900 as compared with the more modern pavements. Figure 3 shows a comparison of repair costs of all pavements laid prior to 1900 with those laid subsequent thereto. It will be observed that in the former the cost increases with the age at a fairly uniform rate. On the other hand the latter shows a marked increase in cost between the tenth and twelfth year; a lower cost after the thirteenth year with another sharp increase after the eighteenth year, which reaches a maximum at the twenty-first year. This diagram indicates a comparatively heavy maintenance period for modern pavements at approximately ten year cycles, the cost increasing with successive cycles. It also shows clearly that the modern asphalt pavement, subjected to modern traffic, is being maintained at a lower cost than those constructed at the earlier periods.

A study of the data from which these diagrams were constructed has disclosed the fact that a surprisingly large number of pavements, considering each separate improvement as a unit, have been in service for many years before requiring any repair. As would be expected, these are light-traffic pavements. For instance, of the one hundred and forty improvements that have been in service ten years with a yardage of 660,000, ninety, comprising a yardage of 323,000, were in service for that period before requiring any maintenance. This represents forty-nine per cent of the yardage of ten year old pavements. It is clear, therefore, that the entire cost of repair for the pavements of this age has been expended on approximately one-third of the improvements and about one-half of the yardage. Of the expenditures made, a large percentage has been on pavements where the traffic has been concentrated in a narrow path. On pavements where the traffic can spread out over the entire surface and not be confined to a narrow path, the maintenance is moderate, even where the traffic is large in volume.

Figure 4 shows graphically the yardage of pavements requiring no maintenance compared with the total yardage at various ages. As would be expected, the percentage decreases very rapidly with the increase in age.

As was noted, the diagram showing repair costs for heavy-traffic pavements indicates a pronounced rise in cost during the earlier ages. The exact period when this rise occurs on an individual pavement is no doubt influenced by several factors, such as sub-soil conditions, construction details and traffic carried, and will vary in different localities. On the pavements under consideration it has occurred from the tenth to the twelfth year after construction. Following this period of abnormal maintenance, there is quite a noticeable reduction in cost for several years. It should be clearly understood, however, that this period of heavy maintenance is not common to all pavements. Our records show, however, that it occurs on most of the heavy-traffic and on some light-traffic pavements.

To illustrate this characteristic, I will cite you the record of a few individual pavements. An

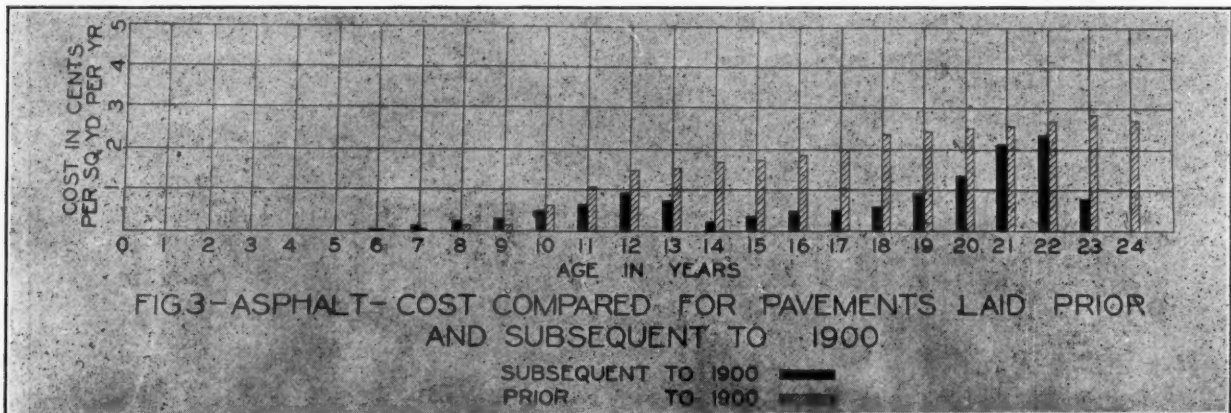


FIG. 3—COMPARISON OF COSTS OF PAVEMENTS LAID PRIOR AND SUBSEQUENT TO 1900.

important thoroughfare in Columbus, which carries a traffic of from twelve to fourteen thousand vehicles daily at the present time, was paved with sheet asphalt in 1911. At the age of eight years, the repair cost on this pavement was \$0.008 per yard per year. At ten years of age it was \$0.045; twelve years, \$0.07, and at thirteen years, \$0.08. We have another thoroughfare in Columbus that was constructed in 1908. This was a brick pavement with a concrete base and tar filler. It receives at the present time traffic of about sixteen thousand vehicles daily. The repair cost of this pavement at eight years of age was \$0.0008, at ten years \$0.026, at twelve years \$0.026, at fourteen years \$0.07 and at sixteen years \$0.18, the last being the peak year. Another pavement fifty feet in width, with a double-track street car line, carrying at the present time from ten to twelve thousand vehicles per day was constructed in 1912. This is a brick pavement with a concrete base and cement-filled joints. It was in excellent condition for an eight-year period, with a repair cost at that age of about one-tenth of a cent per yard per year; but during the last three or four years we have been obliged to give it considerable maintenance, and the cost up to January 1 this year has averaged  $4\frac{1}{2}$  cents per yard per year. In fact, all of the maintenance has been done during the last four years. Probably the most striking example is a sheet asphalt pavement laid on a portion of a thoroughfare leading to the east. This is a street which carries at the present time about twelve thousand vehicles daily, and was constructed on a natural cement base in 1890. In 1901 our record show that this roadway was completely resurfaced and in 1913 it was resurfaced for a second time, by reason of the fact that the asphalt had disintegrated or broken up on account of ground water coming through the foundation. In 1924 this pavement was entirely reconstructed as it had been again largely destroyed in the spring of that year, by water coming through the surface, destroying large areas, and it was considered unwise to attempt to repair or resurface same. In the reconstruction of this pavement a number of sub-drains were laid and an asphalt pavement con-

structed on a new concrete base. This failure was due to an undrained sub-base and a weak foundation, but it is an interesting fact that, in spite of this bad condition, the asphalt surface gave satisfactory service for three successive periods of about eleven years each.

On account of the fact that the period of heavy maintenance is not noticed in all pavements and that its occurrence is uncertain, this period may be called the critical period in the life of pavements. They may pass this period successfully by reason of light traffic or other favorable conditions, or they may develop a weakness before this time by reason of some abnormal condition, but the diagrams seem to indicate that defects, either in sub-base, foundation or wearing surface, do not necessarily develop until this critical period, and we should not form any definite conclusion as to the merits of a pavement until this critical period has been passed.

As indicated by the diagram, the average heavy-traffic pavement after passing this critical period continues to render service at a less repair cost for another period of from ten to twelve years, after which the repair cost reaches a new maximum. One of the important facts developed from these data is that the maintenance cost is moderate for asphalt pavements at all ages, even those thirty to thirty-five years of age, the average cost at the later age being equivalent to about \$425 per mile per year for a pavement eighteen feet wide.

A section of Bryden Rd. was paved with asphalt in 1888. The maintenance cost on this pavement has averaged 3.2 cents per square yard per year for the period of its life, which is equivalent to a cost for upkeep of \$338 per mile per year for a roadway eighteen feet wide. The surface of this pavement, while worn to a thickness of three quarters of an inch or less, is in good condition and carries at the present time a traffic amounting to 7,350 vehicles in a twenty-four-hour day, 15% of which consists of commercial cars.

It should be understood that the repair costs outlined herein cover the maintenance of all asphalt pavements in the city. It includes those constructed from 25 to 35 years ago as well as

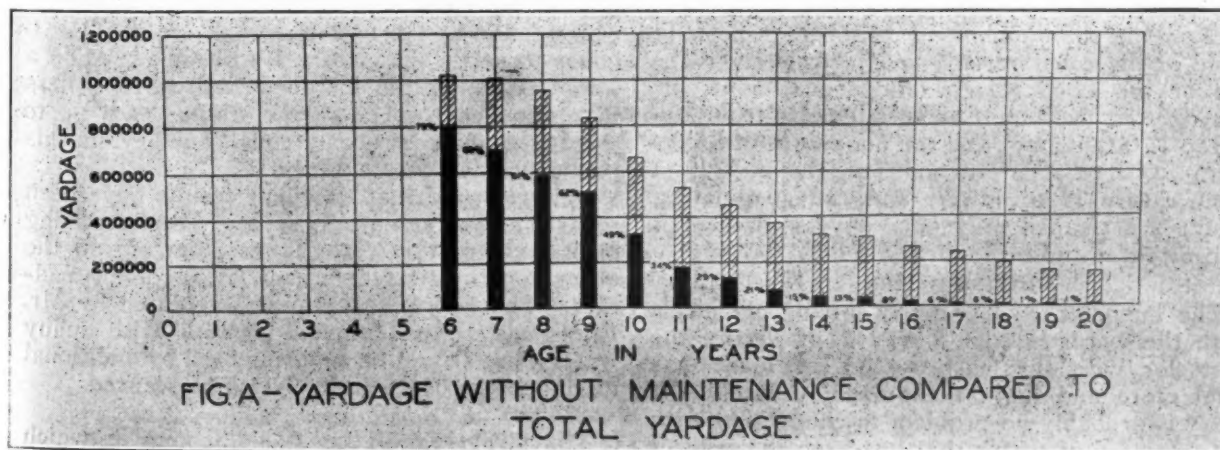


FIG. 4—YARDAGE WITHOUT MAINTENANCE COMPARED TO TOTAL YARDAGE AT DIFFERENT AGES.

those in more recent years; those with a foundation of natural cement concrete as well as those with the modern Portland cement concrete base. It also includes about 195,000 square yards of asphalt surface laid over old boulder and worn out brick pavements. In other words, these are average figures and represent average results obtained from various types of construction and under such traffic conditions as have been common to our cities during the past generation. A few of the older pavements are not as smooth as the demands of motor traffic require, but most of them even at 20 to 35 years of age are carrying present-day traffic in a manner satisfactory to the motor riding public.

### Earth and Gravel Roads Bibliography

The Engineering Societies Library, comprising the libraries of the American Societies of Civil and Mechanical Engineers, the American Institutes of Electrical and of Mining and Metallurgical Engineers, and the United Engineering Society, has prepared a bibliography (S. 4085) of books and articles on earth and gravel roads published between January, 1920, and June, 1925, which contains 140 references with brief annotations. Mimeographed copies may be obtained for \$1.50 each by writing to the Engineering Societies' Library, 29 West 39th Street, New York City.

## Some Features of Filter Design

**Suggestions, based on many years of designing and operating experience, for designing mixing basins, coagulating basins, pipe galleries, filters, and various plant appurtenances. Remarks concerning use of concrete in such structures.**

Many practical suggestions for designers of water filtration plants, both large and small, were given by James W. Armstrong, filtration engineer of the Bureau of Water Supply of Baltimore, in a paper with the above title read before the New England Water Works Association at its recent convention. The more important features of the paper are given in the following paragraphs.

Many features of the filter plant cannot be designed for optimum service without an intimate knowledge of the character of the water to be treated. Some features that need special study with reference to the character of the water are the grit chambers, mixing chamber, coagulating basins, size of sand grains, and the application of chemicals.

The purification process may sometimes be greatly simplified and cheapened by control of the watershed, as by preventing erosion of clayey soils by planting trees, shrubs or grass around the reservoir. If a large impounding reservoir can be created, there generally results a great reduction in the number of bacteria, especially those of the colon variety, and in turbidity. The use of the Loch Raven (Baltimore) reservoir has reduced maximum bacteria counts from 80,000 to 13,000 per c.c., and the maximum turbidity from 5,000 to 200. In addition, the maximum temperature is 6° lower, and the coagulating basins are cleaned only once a year instead of two or three times.

#### MIXING BASINS

The importance of properly mixing chemicals with the water in such a way as to secure the best floc with the least use of coagulant, has been more and more recognized of late. Yet there is probably no problem in connection with the filtration of water that has been the subject of more controversy, unless it be the subject of

filter strainer systems. Many of the smaller plants have no mixing basins at all and seem to get fairly good results, but I believe at an excessive cost for chemicals.

Laboratory experiments indicate that, in order to secure the best results, the water should be violently agitated immediately on application of the coagulant; afterward the agitation may be reduced and excellent results obtained; but if the process is reversed and the coagulant be applied to water that is moving very slowly and with little agitation and is afterwards agitated, no matter how violently, poor or very indifferent results follow.

Possibly mixing basins of the future may combine mechanical agitation with the baffled type of basin. In small plants especially, mechanical agitation might be cheaply and satisfactorily used.

In the common type of mixing basin with around-the-end type of baffles, there is a distinct gain in the subsiding value of the water at each succeeding turn. At Montebello a sample of water taken at the first bend will require 7 or 8 hours to settle sufficiently for filtration, while a sample taken at the 13th bend will settle in less than two hours. The values of the bends up to the 5th seem to be nearly equal, but beyond this the values decrease slightly.

It is reported that excellent results have been secured at Sacramento by several circular mixing basins, where the water flows from one to the other and is agitated in each by revolving paddles. The hydraulic jump as advocated by Mr. Ellms may give splendid results with many waters, but should be supplemented by additional mixing if the best results are to be secured.

#### COAGULATING BASINS

The ideal coagulating basin is one in which the water enters in a thin sheet at the top of one

end, moves uniformly and slowly across the basin, and is withdrawn over a weir at the other end. Such a basin is seldom found because of construction features and difficulty of obtaining complete weir action at the outlet. At Montebello the greatest mud deposits are against the baffle on the incoming side and against the outer wall on the outgoing side and in the corners, where the flow is sluggish.

In an endeavor to secure a more uniform flow and consequently a more uniform deposit of sediment throughout the basin, some submerged cross baffles were built in one of the basins. The design of the baffles was predicated upon two assumptions. If the flow of water could be confined to a thin sheet at the surface, the velocity across the basin would be more uniform, and as the water in the lower part of the basin would be undisturbed, there would be nothing to hinder the settlement of floc. It is a matter of common observation that when flowing water meets an obstruction such as a submerged baffle, there is a tendency to pick up sediment and carry it over the top. In order to prevent sediment from passing the baffle, it was capped with a top made in the shape of a parabola and extending two feet in front.

It was reasoned from the well-known characteristic of a parabola to reflect light in parallel lines, that sediment in the rising current of water would, upon striking the parabola, be thrown downward and deposited instead of being carried over into the next compartment. In order to give a positive outward sweep to the water entering the basin and prevent returning under currents, a wooden apron about two feet wide was built along the top of the entrance baffle. The building of this baffle added greatly to the value of the basin, as the mud was deposited much more uniformly than formerly and immediately after passing the cross baffle there was a marked decrease in the depth of the mud. Cross baffles in coagulating basins would be most effective with waters carrying considerable sediment, but would be of doubtful value with waters of turbidities less than 25.

For cleaning basins a flushing system is entirely satisfactory in most plants, and basins as large as those at Baltimore, which hold thousands of cubic yards of sludge, can be cleaned in 36 hours.

Convenient hose connections should be provided, permitting men to work with a minimum length of fire hose. Hose streams often do not supply sufficient volume of water and larger pipe lines supplying raw water for carrying the sludge to the drains will greatly facilitate the cleaning. With proper flushing devices, a single gutter in the center of an ordinary reservoir will prove satisfactory if the floors and gutters slope sufficiently to give a carrying velocity.

#### PIPE GALLERIES

The crowding of pipes and valves into the pipe gallery ordinarily found in filter plants makes the place inaccessible and consequently neglected

by the employees. In the plant under construction at Montebello, the pipe gallery is unusually free from obstructions. Concrete conduits and compartments have, in most cases, replaced special castings. The controllers are in a pit connecting two concrete compartments, one opening into the filters and the other into a filter effluent conduit.

#### FILTERS

In small plants it is generally possible to satisfactorily operate the filters by means of valves controlled by hand wheels, and in such plants, especially where little money is available, it would be unwise to use hydraulic valves and operating tables.

In earlier plants, wash water gutters discharged into a central gutter but it was found that this in reality gave two separate filters regulated by a single controller. In order to insure the proper and uniform hydraulic grading of the sand in a filter unit there should be no division whatever in the sand area. In a small plant there is no need of a central gutter, and in such plant a large filter unit should not be constructed, as too large a percentage of plant capacity would be put out of service when a unit is being washed.

Concerning the matter of filter bottoms, Mr. Armstrong believes that there is probably no type of strainer system in use which, if properly designed, will not give satisfactory results. With the perforated pipe system the rusting of the pipe and the enlargement of the holes must be counted on. He believes that the slot bottom filters are the most economical and that there is no value whatever in the so-called strainer system with restricted orifices, except to insure proper distribution of wash water through the channels or pipe manifold.

Specifications for filter sand should be prepared for the conditions found at each plant. A water high in turbidity or inorganic matter will require a rather coarse sand of 0.5 to 0.8 millimeter diameter, whereas, if the water is comparatively clear and free from organic matter, a much finer sand is desirable. For mechanical filters it is believed that the term "effective size" is rather misleading because after washing, filter sand becomes hydraulically graded, the fine sand remaining on the top and the coarse settling to the bottom. The effective size therefore is in reality that of the sand directly on the top. These conditions indicate that if an optimum size of sand can once be determined for a given plant, the sand should be as nearly this size from top to bottom as it is possible to secure. A two-foot depth of sand should be enough for any filter and, if the right size is used, good results can be secured with a less depth.

It is usually desirable to provide separate pumps for washing filters, as the draft on the high-pressure lines is too great in most cases. Wash-water tanks, if used, should be placed as near the center of the filters as possible.

In small plants, it is wise to handle chemicals

in barrels or bags as the cost of special machinery for handling them would be unwarranted. In large plants, however, such practice would become a nuisance and provision should be made for using chemicals in bulk to be received in carload lots. Probably the best and the cheapest way of lifting chemicals is by means of a bucket elevator, which necessitates overhead storage bins. For the most economical operation of a large plant there should be no manual labor in connection with handling chemicals, but after first being received at the plant, all handling should be done mechanically. Probably no chemical feed regulators are free from trouble. In plants that use solutions, the corroding and choking of pipes and orifices are a source of endless trouble. Dry feed devices also have their peculiar problems. Use of solutions seems to permit of greater accuracy of control, a factor especially desirable in large plants where slight variations involve large sums of money.

Plants which are manufacturing their own alum seem to be well pleased with results obtained. Most medium or large sized plants have an organization adequate for making alum without additional help, and labor, overhead, profit, and the additional weight of chemicals due to the water of crystallization and the freight thereon, which would be included in a purchased article, may be eliminated. In a well designed alum plant it requires no more labor to manufacture alum than to mix and control chemical solutions.

#### PLANT APPURTENANCES

Mr. Armstrong referred to the use of a potentiometer for recording hydrogen ion concentration of water which had recently been brought to a satisfactory state of perfection by the Leeds-Northrup Co. of Philadelphia working in conjunction with John R. Bayliss, principal sanitary chemist of the Baltimore Filtration Plant. This instrument, he says, is accurate within 1/24 of a pH and has been used at Montebello for some time for determining the amount of lime to be added to the water. It operates red and white lights which inform the attendants whether lime is being applied at the desired rate. The turbidimeter used at Montebello and designed by Mr. Bayliss has been described in *PUBLIC WORKS*. (See issue of October 12, 1924). This gives turbidities accurately to within 1/10 of a part per million. In many plants turbidities are reported at zero when in all probability they are as high as one or more. The author also described the sight glass for determining the clarity of a filter effluent, which was described in the January 7, 1922, issue of *PUBLIC WORKS*.

#### SOME PRINCIPLES OF DESIGN

A fundamental principle of filter plant design is to make it as easy as possible for an operator to do the thing you want him to do, and as hard as possible for him to do the thing that you do not want him to do. Automatic devices in many cases are very desirable, as they can do what no man can do, but they should be so associated with plant operation as to require frequent watching.

Mechanical devices should be the simplest that can be designed to do the work. Crude devices are often very satisfactory.

Cut out all machinery possible, as everything mechanical sooner or later needs repair, and the repairs increase as time goes on.

Access to all machinery, piping, valves and wiring is a great virtue in the eyes of the mechanics responsible for the maintenance of a plant.

Chemicals should be mixed and controlled as near the point of application as possible and open troughs should replace chemical piping if possible.

Beauty often costs no more than ugliness, and in a group of buildings beauty can often be secured by a proper arranging and massing of materials. The ultimate appearance of things should be in the mind of the designer from the inception of his work.

Economy of construction and ease in operation rest with a compactly built plant. Large savings can sometimes be made by making one wall do for two structures.

If filters are built directly over the filtered water basins, the columns and roof of the basin have to be very much heavier in order to carry the weight of the filters, thus generally increasing the cost. Separation of filters and basin will generally result in economy of construction.

When reservoirs are built in excavation, it will be cheaper to slope the sides and pave them with concrete than to build them with either reinforced or gravity walls.

Wherever structures are to be always entirely submerged in water, wood may be substituted safely for concrete. Mixing-basin baffles of wood are much cheaper than of concrete and, in addition, changes can be made more readily and cheaply.

#### CONCRETE

One section of the paper was devoted to discussing the difficulties experienced with concrete as a construction material. In Montebello and in other plants it has been found that after a few years of service certain parts of the concrete begin to disintegrate and Mr. Armstrong believed that the factors of quality of sand and imperviousness of concrete were not considered sufficiently. Disintegration of concrete may sometimes be due to the use of local sand containing impurities of an organic nature that are entirely overlooked. A slight seepage of water through the concrete walls has often been regarded as of little significance, but recent observations seem to indicate that concrete structures through which water is seeping will ultimately fail all together, particularly in places subject to frost action. The calcium compounds are soluble in the presence of most waters. Even calcium carbonate is soluble in waters whose pH value is below the solubility equilibrium. Any water whose pH value is less than 7.5 and whose alkalinity is less than 100 will dissolve calcium.

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# Motor Vehicle Registrations and Revenue, Etc., for Six Months, Ending June 30, 1925

Figures compiled by the Bureau of Public Roads showing, for each state, the number of passenger cars, trucks, cars for hire, official autos and motorcycles; the registration fees received from them; and the rate of gasoline tax and amount received therefrom.

State	Grand tot. motor vehicles 6 months, 1925*	—Individually & commercially owned—		—Registration fees, licenses, permits, etc. Amount applicable to—		—Amount of registration fees paid for—		Grand total motor vehicles first 6 months, 1924	Per cent increase of cars over 1924	Gasoline tax per gallon June 30, 1925	Gross receipts, Jan. 1 to June 30, 1925
		Taxis, busses, and cars for hire	Official trucks and cars owned by State, etc.	Motor cycles	Total gross receipts	Amount applicable to highway work by or under supervision of State highway department	Passenger cars				
Alabama	236,966	39,547	858	361	\$1,892,557	\$1,845,525	.....	154,234	53.6	2	\$963,520
Arizona	59,809	8,142	858	286	3,124,855	2,647,335	.....	150,409	18.6	3	401,738
Arkansas	148,981	19,131	19,750	185	2,924,180	2,647,335	.....	116,700	27.6	4	1,820,739
California	1,317,825	198,618	19,750	9,737	6,558,101	3,979,050	\$3,746,835	1,184,015	11.3	2	7,514,667
Colorado	213,391	15,660	3,151	1,488	1,311,363	601,000	1,055,598	189,756	14.4	2	914,962
Connecticut	216,746	30,094	3,151	3,097	5,069,155	5,069,155	2,948,033	1,080,491	15.0	2	527,671
Delaware	35,690	6,200	...	235	613,474	613,474	354,804	126,484	13.7	2	157,291
Florida	231,439	36,500	...	730	3,017,502	1,918,034	.....	164,112	41.0	3	2,731,387
Georgia	207,663	24,968	...	731	2,720,157	2,650,051	2,229,660	439,447	17.3	3	1,837,203
I Idaho	73,500	4,500	970	456	1,426,190	1,356,525	.....	62,175	18.2	3	339,466
Illinois	1,123,084	141,638	308	5,166	12,032,287	12,007,333	8,702,662	986,480	13.8	0	3,399,466
Indiana	523,783	68,685	308	3,639	4,279,463	4,139,170	3,058,320	581,899	(*)	3	3,214,588
Iowa	611,002	41,832	2,000	2,074	8,969,441	8,162,191	.....	565,415	7.0	2	978,855
Kansas	406,930	40,719	1,884	1,046	4,476,590	4,297,814	.....	360,796	12.8	2	892,208
Kentucky	233,828	208,305	1,447	548	3,585,157	3,541,137	2,724,616	203,028	15.1	3	1,347,499
Louisiana	190,896	161,826	...	505	3,112,947	3,112,947	.....	150,000	27.2	2	1,091,691
Maine	126,200	18,295	...	1,200	1,905,724	1,905,724	1,426,601	110,282	14.4	*1	202,477
Maryland	208,338	194,766	...	3,719	2,063,432	1,952,027	250,447	178,153	16.9	2	870,975
Massachusetts	639,315	87,752	3,233	8,155	7,926,862	7,734,116	5,186,065	508,997	25.6	0	3,385,500
Michigan	798,460	716,233	3,233	2,540	11,763,067	5,763,067	2,481,847	764,423	4.4	2	3,385,500
Minnesota	519,168	479,629	...	2,622	9,037,663	9,037,663	7,867,097	462,777	12.1	2	1,260,839
Mississippi	148,758	43,676	...	1,583	1,413,894	1,413,894	1,271,879	112,099	32.6	3	1,079,701
Missouri	535,528	48,382	1,410	1,922	3,250,206	3,022,652	.....	477,056	12.2	3	2,169,902
Montana	83,950	10,600	594	1,922	837,550	.....	711,081	65,100	21.5	2	266,229
Nebraska	295,341	30,561	350	868	3,625,172	2,718,879	2,951,971	273,236	8.1	2	681,215
Nevada	17,939	2,869	286	76	188,891	188,891	.....	15,961	12.4	2	100,228
New Hampshire	73,120	65,808	286	1,304	1,045,654	990,051	.....	64,373	13.6	2	263,027
New Jersey	505,474	397,379	...	6,175	9,198,365	9,026,280	3,864,491	435,894	15.9	0	.....
New Mexico	42,205	1,267	10,624	184	445,628	261,557	.....	34,951	20.7	3	185,019
New York	1,404,653	237,233	20,442	15,737	23,057,565	17,293,174	14,057,217	1,233,362	13.3	0	2,782,242
North Carolina	315,000	282,750	...	*1,000	4,983,700	4,490,000	.....	285,546	10.3	4	2,782,242
North Dakota	126,106	118,624	...	321	918,994	319,497	822,731	104,845	20.3	1	250,150
Ohio	1,292,000	180,000	3,000	12,000	11,969,324	5,984,662	.....	1,166,000	11.3	2	251,435
Oklahoma	420,000	30,000	1,577	800	4,112,723	3,558,232	4,059,690	308,906	35.9	3	2,160,649
Oregon	179,586	166,107	1,577	2,069	4,844,310	3,558,232	682,825	161,729	11.0	3	1,336,593
Pennsylvania	1,205,237	162,307	8,880	13,180	19,526,528	19,526,528	10,755,719	1,085,285	11.1	2	4,657,752

State	Individually & commercially owned—			Registration fees, licenses, permits, etc.			Amount of registration fees paid for—		Grand to—Per cent		Gross receipts, Jan. 1 to June 30, 1925
	Grand tot. motor vehicles 6 months, 1925 <sup>1</sup>	Passenger cars <sup>2</sup>	Motor and trucks <sup>3</sup> for hire by State, etc. <sup>4</sup>	Taxis, busses, trucks owned	Official cars and trucks owned by State, etc. <sup>5</sup>	Motor cycles	Total gross receipts	Passenger cars	Motor trucks	tal motor vehicles first 6 months, 1924	
Rhode Island.....	89,247	72,603	15,311	1,333	587	1,054	1,520,703	946,248	357,323	78,413	45,848
South Carolina.....	141,202	128,735	12,467	398	1,149	280	1,553,991	1,553,991	295,011	137,891	1,583,910
South Dakota.....	150,332	138,257	12,075	1,937	712	280	2,279,479	2,039,291	234,768	126,813	1,380,898
Tennessee.....	218,735	196,389	22,346	1,937	...	554	2,808,119	...	...	182,723	2,113,572
Texas.....	848,661	773,464	72,505	2,692	...	2,201	12,081,524	8,676,392	...	661,919	429,862
Utah.....	76,410	66,850	9,560	...	...	576	496,851	437,200	...	67,133	171,867
Vermont.....	60,424	56,083	4,341	...	...	1,500	1,350,639	1,279,362	...	52,614	1,881,786
Virginia.....	226,800	222,500	3,300	...	...	1,500	3,813,317	3,617,680	...	225,343	1,445,786
Washington.....	293,559	250,257	40,321	3,001	3,789	2,196	4,615,950	3,392,992	978,430	265,541	632,280
West Virginia.....	184,200	158,400	25,800	3,350	1,135	2,864	2,898,418	2,030,637	493,638	154,772	779,838
Wisconsin.....	53,682	476,188	58,474	(*)	1,437	200	7,800,438	...	...	473,913	130,190
Wyoming.....	33,000	4,600	28,400	...	200	200	437,000	...	...	38,200	389,391
Dist. of Columbia...	32,427	71,158	10,631	638	1,939	1,324	105,278	...	...	72,954	...
Total.....	17,716,709	15,519,647	2,114,750	82,312	70,200	119,274	\$226,899,709	\$183,780,371	\$42,761,206	15,552,077	\$60,108,734

\* Approximate.

\* Only data for 27 States shown.

\* Estimated from 3 months' return.

\* Official exempt cars and trucks.

† Decrease.

1 Net number of cars and trucks registered shown when possible, excluding reregistrations, nonresident, and official exempt cars and trucks.  
 2 Recorded with private cars or trucks. 3 Motor busses only.  
 4 Estimate for registration year ending June 30.  
 5 Changed to 3 cents July 11.  
 6 Changed to 4 cents July 1.

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carbonate. When the calcium compounds are being dissolved, this usually is indicated by white efflorescence on the surface of the concrete, although when the concrete is submerged this is not evident. In addition, the aluminum compounds are slowly and gradually dissolved. The leaching out of these chemical compounds robs the concrete of its strength and makes it very susceptible to the disintegrating action of frost. At Montebello the concrete at first appeared to be of very excellent quality, but after a few years, each succeeding winter saw increased spalling of the concrete and at the present time some of the baffle walls have become completely disintegrated near the water surface, while others are apparently in good condition. This danger of disintegration of concrete should warn designers not to adhere too closely to theoretical dimensions in designing concrete walls and other structures.

### California Water Breaks Abolished

On the roads crossing the Sierras, most of which are unsurfaced, it has been the practice to construct what is known as water breaks (similar to New England "thank-you-ma'am's") for diverting the surface flow at intervals to the side of the road. As built in the high Sierras, these were formidable objects, being constructed by placing a small log or a row of rocks diagonally across the road and covering them with a mound of earth, which, when compacted, formed a ridge 12 to 15 inches high. The chief purpose of this was to serve, when the snow began to melt in the spring, to divert the water flowing under the snow to the gutters or lower side of the embankment, to prevent the wearing of deep longitudinal gullies in the surface of the road.

Following the construction of two as an experiment last year, about 270 water breaks were replaced this year by flat-top wooden culverts. These are ordinary wooden box culverts, the top of which consists of three or four 4x4-inch timbers placed one inch apart longitudinally to the culvert or diagonally to the road, the top being set flush with the road surface. These serve to carry the gutter drainage from one side of the road to the other and also to intercept the surface flow and conduct it to the lower end of the culvert. The top is removable to permit cleaning the culvert. The cost of a culvert is little more than that of constructing and removing a water break, while they offer little appreciable interference with the comfort of travel.

### Wisconsin Road School

The Wisconsin Highway Commission announces that the 15th annual road school of the Wisconsin County Highway Commissioners Association will be held at the State Capitol from January 25 to 29, and not from February 8 to 12 as previously announced, because of the fact that other conventions are to be held in Madison during the latter week.